

## CHAPTER 3

# MK 7 AIRCRAFT RECOVERY EQUIPMENT

Present-day aircraft normally require the use of runways that are 5,000 to 8,000 feet long in order to land ashore. On an aircraft carrier, these same aircraft are stopped within 350 feet after contacting the deck. This feat is accomplished through the use of aircraft recovery equipment, including an emergency barricade that brings a landing aircraft to a controlled stop by absorbing and dispelling the energy developed by the landing aircraft. This recovery equipment is commonly called arresting gear.

The sole purpose of an aircraft carrier is to provide a means of launching a strike against an enemy anywhere in the world. After the aircraft complete their mission, the carrier must provide a means of safely recovering them. The Mk 7 arresting gear provides this means.

### AIRCRAFT RECOVERY

**LEARNING OBJECTIVE:** Describe aircraft arrestments aboard aircraft carriers. Describe prerecovery preparations. Describe normal aircraft recovery operations. Describe emergency aircraft recovery operations.

Aircraft arrestments aboard carriers are classified as either a normal arrestment or an emergency arrestment. Simply stated, arrestment is accomplished in the following manner: the arresting hook of the incoming aircraft engages a wire rope cable, called a deck pendant, that spans the flight deck in the landing area. The force of the forward motion of the aircraft is transferred to purchase cables that are reeved around a movable crosshead of sheaves and a fixed sheave assembly of the arresting engine (see fig. 3-1). The movable crosshead is moved toward the fixed sheave assembly as the aircraft pulls the purchase cables off the arresting engine, forcing a ram into the cylinder holding pressurized hydraulic fluid (ethylene glycol). This fluid is forced out of the cylinder through a control valve that meters the flow to an accumulator until the aircraft is brought to a smooth, controlled arrested landing (see fig. 3-2).

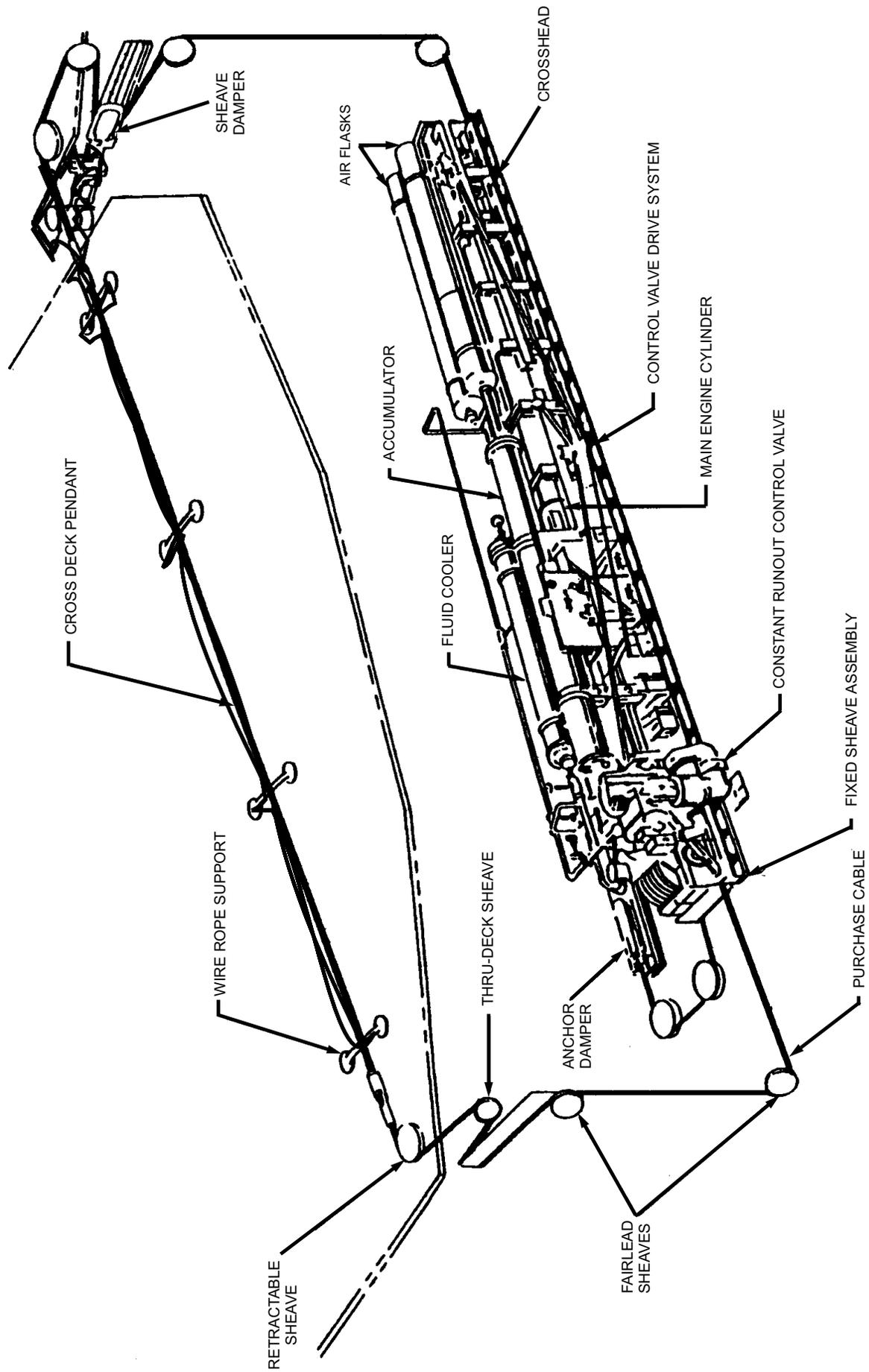
After arrestment, the aircraft's arresting hook is disengaged from the deck pendant. A retract valve is

then opened, allowing fluid to be forced from the accumulator back into the engine cylinder, forcing the ram out. As the ram moves out of the cylinder, the crosshead is forced away from the fixed sheave assembly, pulling the purchase cables back onto the engine until the crosshead is returned to its BATTERY position and the crossdeck pendant is in its normal position on the flight deck.

### PRERECOVERY PREPARATIONS

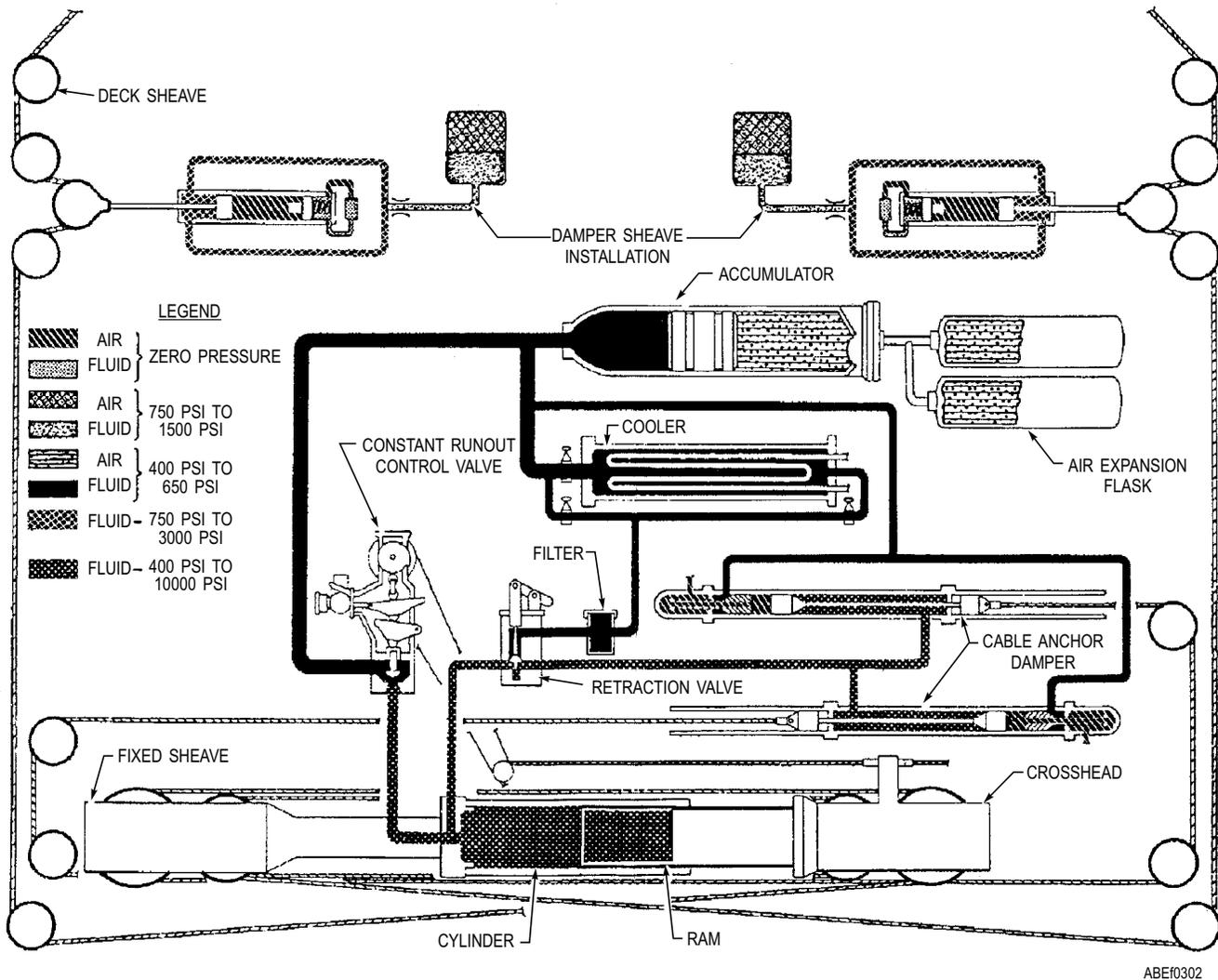
Prior to recovery of aircraft, all recovery equipment and landing area must be made ready and all personnel properly positioned. The following is a general listing of the events that must be accomplished prior to the recovery of aircraft:

- All operational retractable sheaves raised to the full up position
- All aft deckedge antennas positioned, as required
- Ready barricade, including deck ramps, in a ready status with a clear route to the landing area and a tractor with driver standing by
- All launching accessories clear of the landing area
- Appropriate catapult shuttle(s) (as applicable) are aft with the grab latch disengaged and the shuttle spreader cover installed
- The catapult centerdeck hatch and any other hatches in the waist catapult area closed and dogged down
- Jet Blast Deflectors (JBDs) completely lowered and hydraulics secured
- Waist catapult safety light in the down position, if applicable
- Catapult #3 track slot buttons installed
- Waist catapult Integrated Catapult Control Station (ICCS) fully lowered, if applicable



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Figure 3-1.—General arrangement of Mk 7 arresting engine with cooler.



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Figure 3-2.—Mk 7 Mod 3 fluid flow diagram during arrestment.

- Landing area clear of aircraft or any other obstructions
- Aircraft recovery green rotating beacon on
- All stations manned and ready with voice communication established and reports made to the air officer
- Sheave and anchor damper in the battery position
- All engines fully retracted and crossdeck pendant at the proper height
- Engine fluid levels in the battery range and accumulator pressure at 400 psi
- Received from the air officer; aircraft type to be recovered
- Determine proper aircraft weight setting in accordance with applicable aircraft recovery bulletin
- Direct the engine room operators to set their respective engine and verify that correct weight has been set
- Pickle switch is actuated, lighting the green clear deck landing status light

### NORMAL RECOVERY OPERATIONS

Normal recovery operations involve the recovery of aircraft with no equipment failure or damage that precludes the aircraft from recovering at the prescribed air speed or proper landing configuration.

Prior to commencing aircraft recovery operations, the following considerations apply:

All arresting gear equipment is in normal operating condition and all Maintenance Requirement Cards (MRCs) preoperational requirements have been met.

All personnel involved in recovery operations have completed the applicable Personnel Qualification Standards (PQS) and are fully qualified to perform their assigned tasks. Personnel not yet qualified may be utilized, but only if under the direct supervision of a fully PQS qualified crewmember.

## **EMERGENCY RECOVERY OPERATIONS**

An emergency arrestment is accomplished in the same manner as a normal arrestment except that a barricade webbing assembly transmits the aircraft's landing force to the purchase cable instead of a crossdeck pendant.

### **ARRESTING ENGINE**

**LEARNING OBJECTIVE:** Describe the components of the arresting engine.

The Mk 7 arresting engine is a hydropneumatic system composed of the engine structure, a cylinder and ram assembly, a crosshead and fixed sheaves, a control valve system, an accumulator system, air flasks, and a sheave and cable arrangement.

Improvements are continuously being made to increase the capabilities of carrier-based aircraft. As the capabilities of the aircraft are increased, the weight and speed also increase. Therefore, the equipment used to recover the aircraft aboard carriers must also be improved to keep pace with aircraft advancement. Such improvements have brought about the recovery equipment installed on our carriers in the fleet today—the Mk 7 Mod 3.

All pendant and barricade engines are Mk 7 Mod 3, except the barricade engines installed on CV-64 and CVN-65, which are Mk 7 Mod 2. For more information on the Mk 7 Mod 2 refer to *Operational and Organizational/Intermediate Maintenance Manual, NAVAIR 51-5BBA-2.1 and 2.2*. Table 3-1 lists the leading particulars of the Mk 7 Mod 3 recovery equipment.

## **ENGINE STRUCTURE**

The engine structure is a framework for supporting the engine and most of its components and for securing the entire assembly to the ship's structure. It is composed of a welded steel base made in two longitudinal box sections with the necessary ties, plates, and other structural members. The two sections are bolted together near the center. See figure 3-1.

Two pairs of saddles are mounted on the base for supporting the engine cylinder. Vertical stands are welded on these saddles to support the saddles for the accumulator. Between these two stands is a frame of welded channels, angles, and gusset plates to provide trusses and ties for the frame.

On the crosshead end of the welded base support plates, webs and gussets support the rails for the crosshead. On this end of the base are welded longitudinal guides for the accumulator assembly. Near the end of this frame and bolted to it is the crosshead stop, which is removed when the crosshead is installed or removed.

### **CONSTANT RUNOUT VALVE (CROV) ASSEMBLY**

The constant runout valve (CROV) is installed at the fixed sheave end of the Mk 7 arresting engine, as illustrated in figure 3-1. It is designed to stop all aircraft with the same amount of runout regardless of the aircraft's weight and speed (within the limits specified in current recovery bulletins).

The CROV is the heart of the equipment. It controls the flow of fluid from the cylinder of the arresting engine to the accumulator. The other components of the valve are used either to adjust the initial opening of this valve for aircraft of different weight or to activate the valve during the arresting stroke.

### **CONSTANT RUNOUT VALVE (CROV) DRIVE SYSTEM**

When a landing aircraft engages a deck pendant, or barricade, it withdraws purchase cable from the arresting engine. This action causes the crosshead to move toward the fixed sheave end of the engine. In addition to causing fluid displacement from the engine cylinder, the movement of the crosshead causes the CROV drive

**Table 3-1.—Leading Particulars of Mk 7 Mod 3 Recovery Equipment**

MAXIMUM ENERGY ABSORPTION	47,500,000 ft-lb
<b>ENGINE DRIVE SYSTEM CABLES:</b>	
Breaking strength/diameter	
Deck pendant (6 × 30 flat strand hemp core)	188,000 lb/1 3/8 in.
Purchase cable (6 × 25 round strand hemp core)	195,000 lb/1 7/16 in.
Deck pendant (6 × 30 flat strand polyester core)	205,000 lb/1 7/16 in.
Purchase cable (6 × 31 flat strand polyester core)	215,000 lb/1 7/16 in.
Reeving ratio	18 to 1
<b>3312DAMPER SHEAVE INSTALLATION:</b>	
Damper sheave service stroke	10 ft
Effective piston area of damper sheave piston	39.27sq. in.
<b>ARRESTING ENGINE:</b>	
Length	50 ft
Weight	43 tons
Engine fluid	Ethylene glycol
Engine fluid capacity (without cooler)	380 gal
Engine fluid capacity (with cooler)	560 gal
Type of coolant	Sea water
Ram diameter	20.000 in.
Effective ram area	314.16 sq. in.
Length of two-stroke	195 in.
Length of service stroke	
Pendant engine	183 in.
Barricade engine	160 in.
Crosshead battery position	1 to 7 in. (new cable)
(distance from stop)	1 to 6 in. (old cable)
Accumulator operating medium	Hydraulic fluid — Air
Initial working pressure	400psi
Maximum pressure	650 psi
Length of deck pendant runout	344 ft (to tail hook)
Length of barricade runout	388 ft (to nose wheel)
Cable anchor damper piston service stroke	15 ft 8 in.
Effective piston area of cable anchor damper piston	7.85 sq. in.
<b>BARRICADE POWER PACKAGE</b>	
Power package fluid	Catapult hydraulic fluid
Power package fluid capacity	125 gal
Power package operating medium	Hydraulic fluid — Air
Initial working pressure	1,500 psi
Pressure switch minimum pressure	1,250 psi
Relief valve maximum pressure	1,750 psi

system (fig. 3-3) to rotate the CROV cam. Rotation of this cam forces a plunger down onto a set of levers (fig. 3-4), which in turn forces a valve sleeve and valve stem down to mate with a valve seat to close the valve, shutting off the flow of fluid from the engine cylinder to the engine accumulator, bringing the aircraft to a stop.

As stated earlier, the CROV is designed to bring all aircraft, regardless of weight, to a controlled stop while using approximately the same amount of flight deck landing area. This is accomplished by adjusting the allowable opening of the CROV, a smaller, more restrictive opening to arrest a heavy aircraft or a large valve opening to arrest a light aircraft.

### CONSTANT RUNOUT VALVE (CROV) WEIGHT SELECTOR

The aircraft weight selector makes it possible to adjust the CROV for aircraft of different weights by varying the valve opening. See figure 3-4.

The size of the initial valve opening is adjusted while the arresting engine is in the BATTERY position. The lead screw receives rotary motion from the motor unit or handwheel and converts it into linear motion. This linear motion positions the upper lever and drives the local and remote indicators.

In each of the two levers (upper and lower), the distance between the fulcrum and roller is constant. On the upper lever, the distance between the fulcrum and

the point of application of force from the cam is variable, its greatest length being twice that of the lower lever. The lever arm ratio of each lever, therefore, is variable between 1:1 and 2:1.

When the upper lever is fully extended, the ratio of each lever is 1:1. In this setting the initial opening of the control valve upon engagement of an aircraft is maximum. The resulting rotation of the cam, caused by the crosshead moving inward, forces the plunger downward. A plunger movement of 1 inch, acting through the upper lever, would move the lower lever 1 inch; the lower lever, in turn, would move the valve sleeve and stem 1 inch downward.

The cam is a disc plate type with the desired contour machined on its periphery. As the cam rotates, it forces the plunger down. The plunger is fitted with rollers, top and bottom.

The bottom roller on the plunger acts against the top flat bearing surface of the upper lever. The pivot end of the upper lever has a bushed hole that mates with the clevis end of the lead screw yoke. The upper lever is connected to the clevis end of the yoke by a pin. This pin extends beyond the sides of the yoke and acts as a shaft and has a bushed roller mounted on each extended end. The rollers ride inside the guide attached to the housing. The block end of the yoke is connected to the lead screw by two dowel pins. This connection provides the means by which the lead screw adjusts (moves) the upper lever.

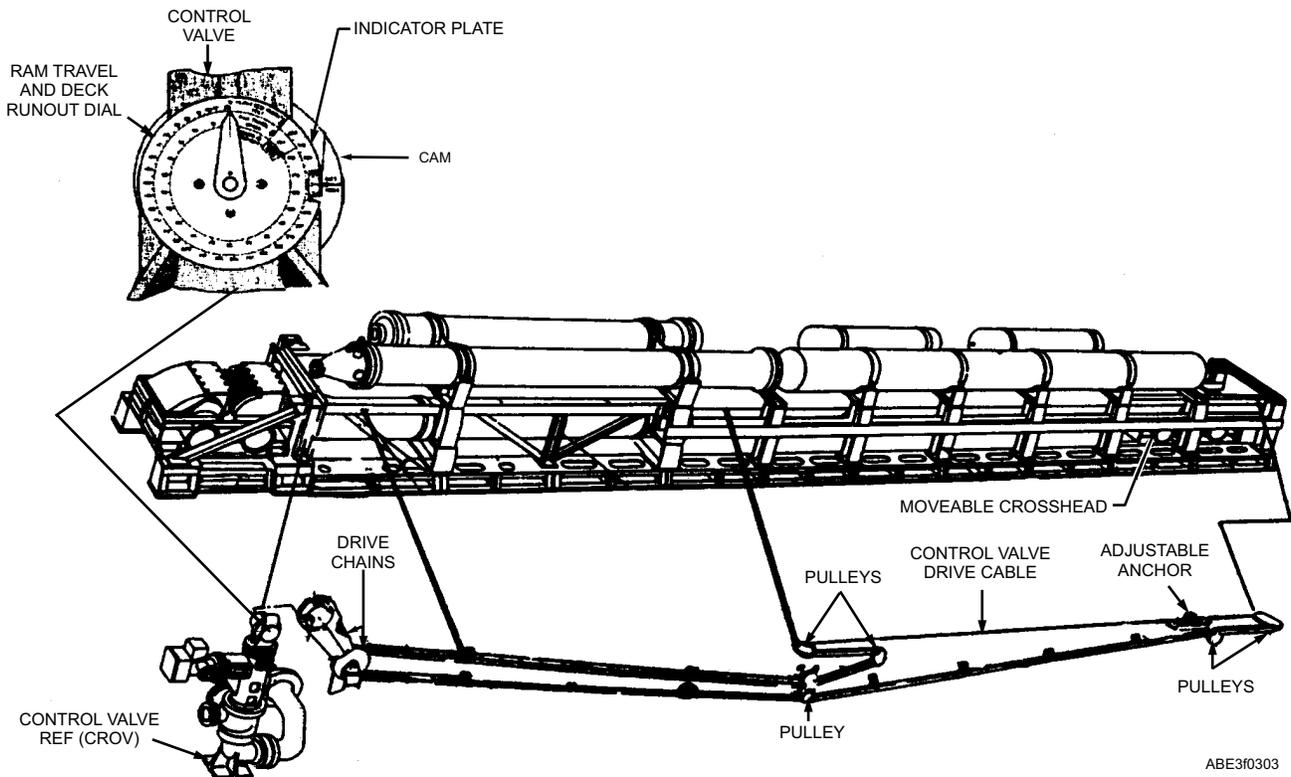


Figure 3-3.—Constant runout valve drive system.

The bottom of the upper lever is fitted with a roller that bears against the flat surface of the lower lever. One end of the lower lever has a bushed hole to receive a pivot pin. The pivot pin passes through the lever and through two mounting holes in the stanchion.

The bottom of the lower lever is fitted with a roller that bears on the stem screw on top of the valve sleeve. The vertical position of the roller on the lower lever determines the vertical distance that the valve sleeve may move. Thus, it controls the size of the initial opening of the control valve.

The levers are mounted in such a way that, as the upper lever is withdrawn, the lever arm ratio of both levers is increased by an equal amount. When the upper lever is fully withdrawn, the ratio of each lever is 2:1, and the ratio through the lever system (upper and lower levers) is 4:1. In this case the initial control valve

opening is minimum. A plunger movement of 1 inch, acting through the upper lever, would move the lower lever 1/2 inch; the lower lever, in turn, would move the valve sleeve and stem 1/4 inch downward.

A critical point to consider is the position of the levers when the valve stem is seated by cam action at the termination of each arrestment stroke. The levers are so mounted and adjusted that the bearing surfaces of the levers are level when the valve is seated. When the bearing surfaces are level, the distance across the lever system is the same regardless of the ratio setting. Because of this, the point of closing of the valve is independent of the aircraft weight selector. It is a function of the cam only; therefore, it is constant.

As the engine is retracted, the upper lever rises a distance equal to the movement of the plunger. If the ratio is 1:1, the valve sleeve rises the same distance. In

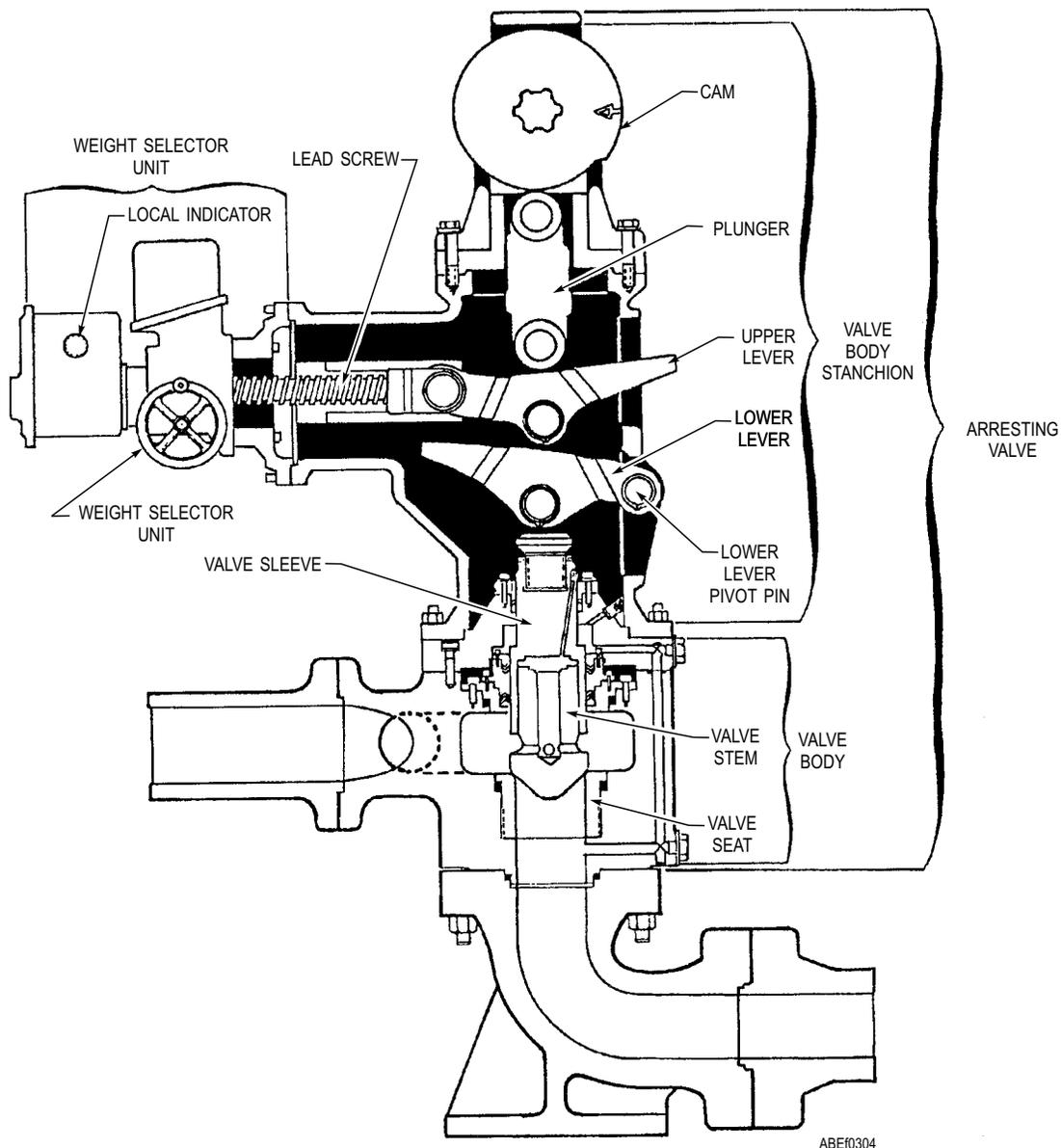


Figure 3-4.—Sectional view of Mk 7 CROV.

this case the initial valve opening is maximum. If the ratio is 4:1, however, the valve sleeve rises only one-fourth the distance that the plunger moves. In this case the initial valve opening is minimum.

The lever setting may be adjusted to any setting within the two extremes previously discussed; the particular setting used is dependent upon the weight of the aircraft to be arrested. The weight setting is made with the engine in battery position prior to landing the aircraft.

Adjustment of the setting determines the position of the valve sleeve. Therefore, it also sets the amount the valve will open at the beginning of the arrestment stroke. Similarly, it determines the rate of closure during the stroke so that the valve will always seat at the same runout.

The valve stem sleeve allows a relatively unloaded and cushioned opening at the beginning of the stroke.

The lever system, if set for a heavy aircraft, reduces the allowable valve stem opening and thus increases the resistance of the valve to the flow of fluid. The energy of the aircraft is dissipated by forcing fluid through the restricted valve opening.

### ELECTRICAL SYSTEM

The electrical system provides, controls, and safeguards the distribution of electrical energy to the weight selector motor and the synchro indicators. The

electrical circuits (fig. 3-5) are the control valve weight selector circuit and the indicator circuit.

### AIRCRAFT WEIGHT SELECTOR SYSTEM AND ELECTRICAL CIRCUIT

Due to the varying weights and landing speeds of carrier-based aircraft, it is necessary to vary the initial opening of the CROV and have a smaller initial opening for heavier aircraft than for lighter aircraft. The variation of the setting of the CROV is the function of the aircraft weight selector motor unit. (See fig. 3-5.) Normally, the settings are made electrically by depressing an increase or decrease push button located at the control valve. The settings can also be accomplished manually by a handwheel at the control valve.

The aircraft weight selector is motor operated from the 440-volt, 60-hertz, 3-phase ship's power supply. A fused switch box or breaker is provided to energize or de-energize the control circuit. To increase and decrease settings, the direction of the aircraft weight selector motor rotation is controlled by the motor controller. Should an electrical failure occur, the settings can be made manually by pulling out on the handwheel and turning in either the increase or the decrease direction.

Settings on the aircraft weight selector are monitored locally at the control valve motor unit dial and remotely by synchro receivers located at Pri-Fly and the deckedge control station.

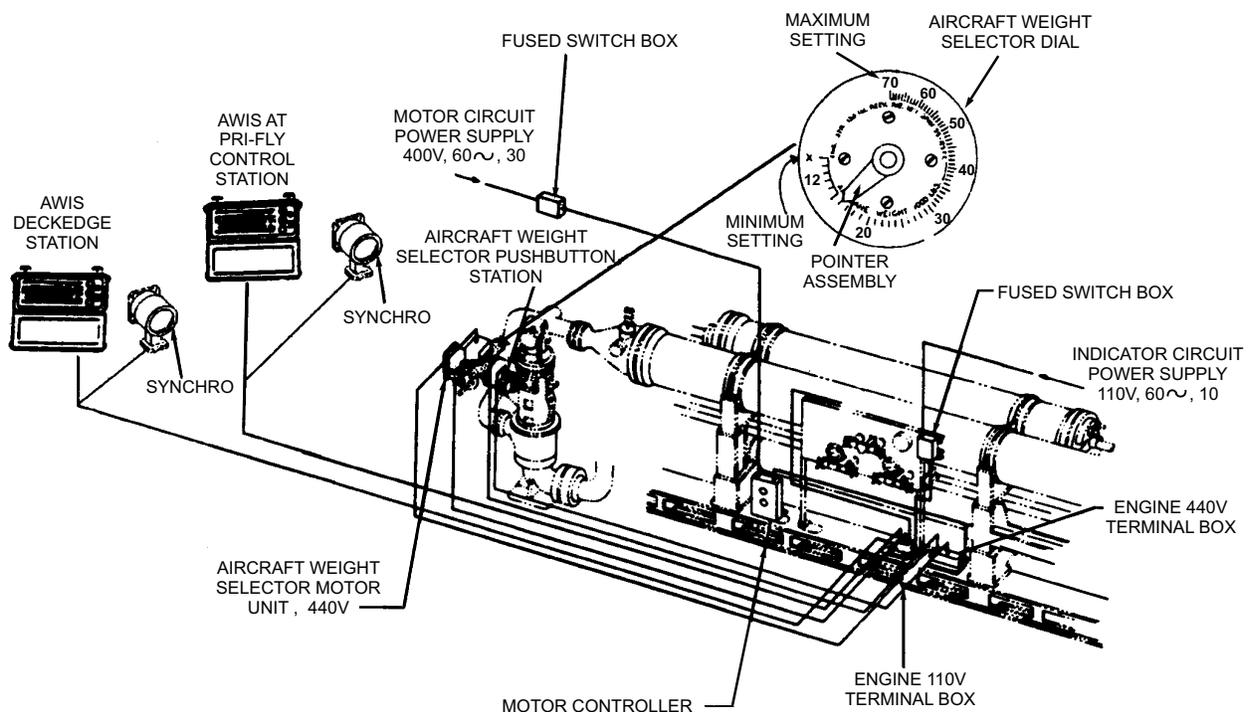


Figure 3-5.—Aircraft weight selector system.

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## PUSH-BUTTON STATIONS

The function of the push-button station is to select the proper contact of the weight selector motor controller so as to rotate the shaft of the motor in the proper direction to increase or decrease the weight setting

## DECKEDGE CONTROL STATION

The deckedge control station (fig. 3-6) is located on the starboard side aft, where the operator has a clear, unobstructed view of the landing area.

The deckedge control station is equipped with control levers to retract each of the pendant engines and

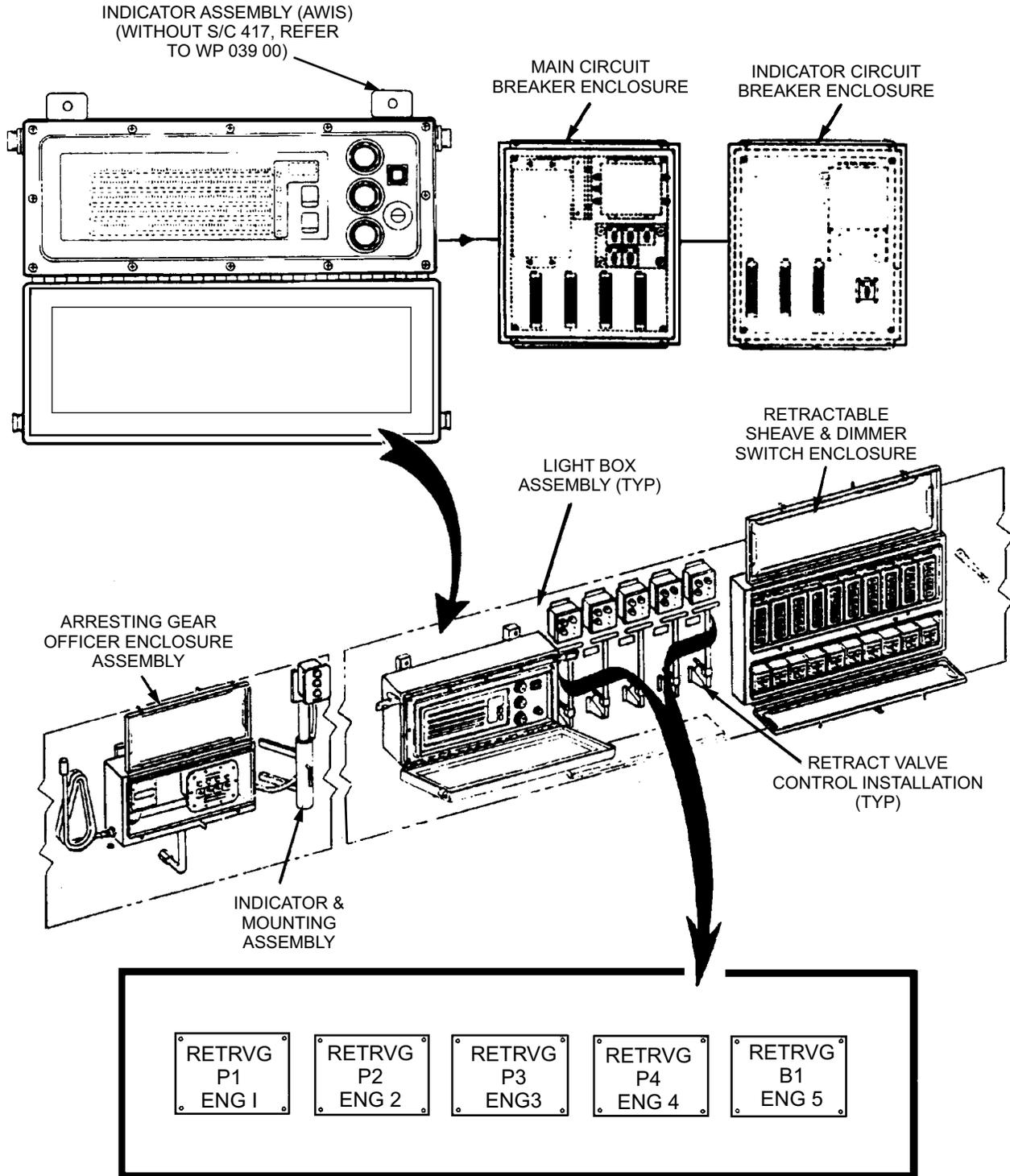


Figure 3-6.—Deckedge control station.

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the barricade; a pressure gauge for the barricade hydraulic system; a control lever to raise or lower the barricade stanchions; push buttons to raise, lower, or stop the retractable sheaves; an indicator light to indicate their position; a battery position indicator light for the damper sheaves; and synchro receivers to monitor settings on the aircraft weight selector unit of each engine.

The deckedge control operator operates the controls from the gallery walkway and is equipped with sound-powered phones to maintain voice communications with the engine-room operator and Pri-Fly.

### RETRACTING VALVE

The retracting valve permits the controlled return of fluid from the accumulator to the cylinder, thereby returning the engine to the BATTERY position. The general location of the retracting valve is shown in figure 3-7.

The retracting valve is a self-contained poppet-valve assembly composed principally of a housing, a plunger, an operating lever, a valve stem, and a valve seat.

The retracting valve operates as a check valve against the flow of fluid from the accumulator to the engine cylinder. Fluid at accumulator pressure enters the housing and bears on the stem in the direction that would open the valve; however, the pressure also bears against the base of the plunger, which tends to close the valve. Since the area of the plunger end is greater than that of the stem, the differential in force keeps the valve closed.

The retracting valve has piping that provides passage for engine fluid flow from the arresting engine, by way of the retracting valve, to the cable anchor dampers. A discharge port is provided where the retracting valve and pressure valve body are bolted together to allow fluid flow from the accumulator or fluid cooler into the main engine cylinder during retraction.

### Retracting Valve Body

The retracting valve body is a hollow steel casting with an inlet port, connected by piping to the engine accumulator/fluid cooler manifold, a discharge port that is flanged and bolted to the engine cylinder outlet elbow, and a port connected by piping to the cable anchor dampers.

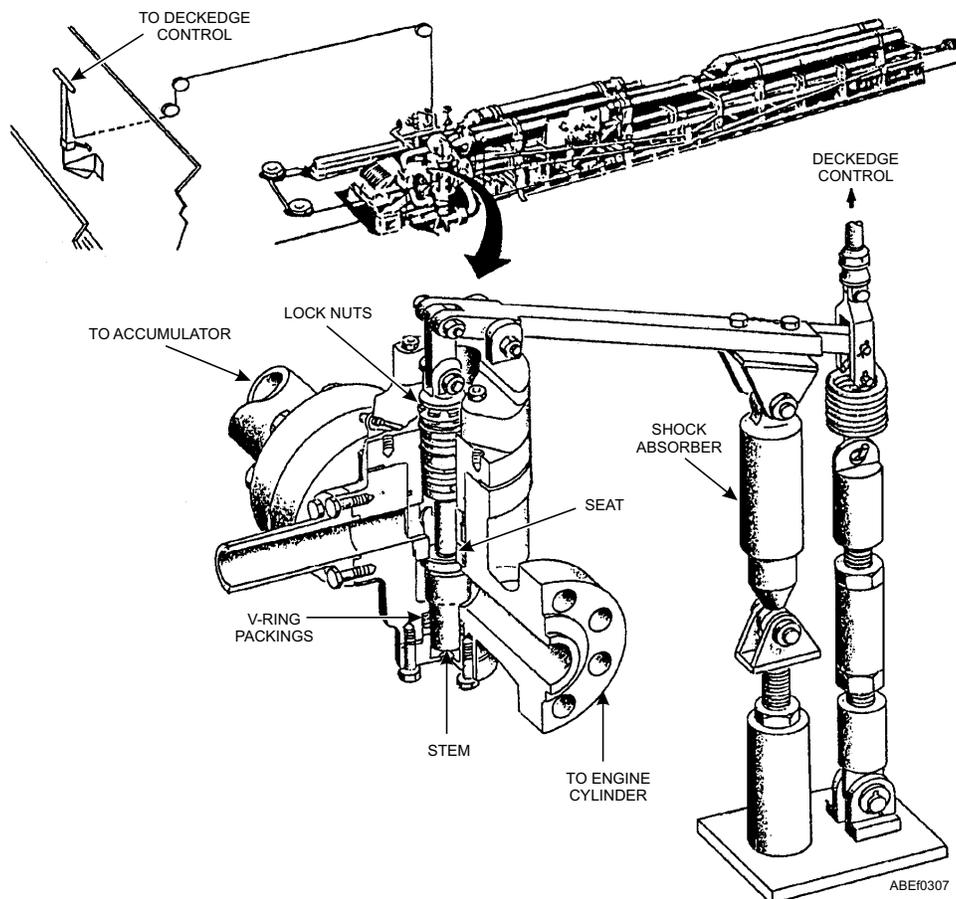


Figure 3-7.—General location of the retracting valve.

The valve body is bored and machined smooth inside to receive the valve seat. O-rings are provided as a seal between the valve body and the seat. The lower portion of the valve body has an inside machined recess for insertion of a V-ring packing assembly. The V-ring packing prevents leakage between the stem and valve body.

### Valve Seat

The valve seat is a hollow, machined, cylindrical piece of bronze. One end is flanged and is bolted to the valve body, and the opposite end is machined to form a mating surface (seat) for the valve stem. Four vertical elongated holes are machined in the seat to allow fluid to enter the valve from the accumulator.

### Valve Stem

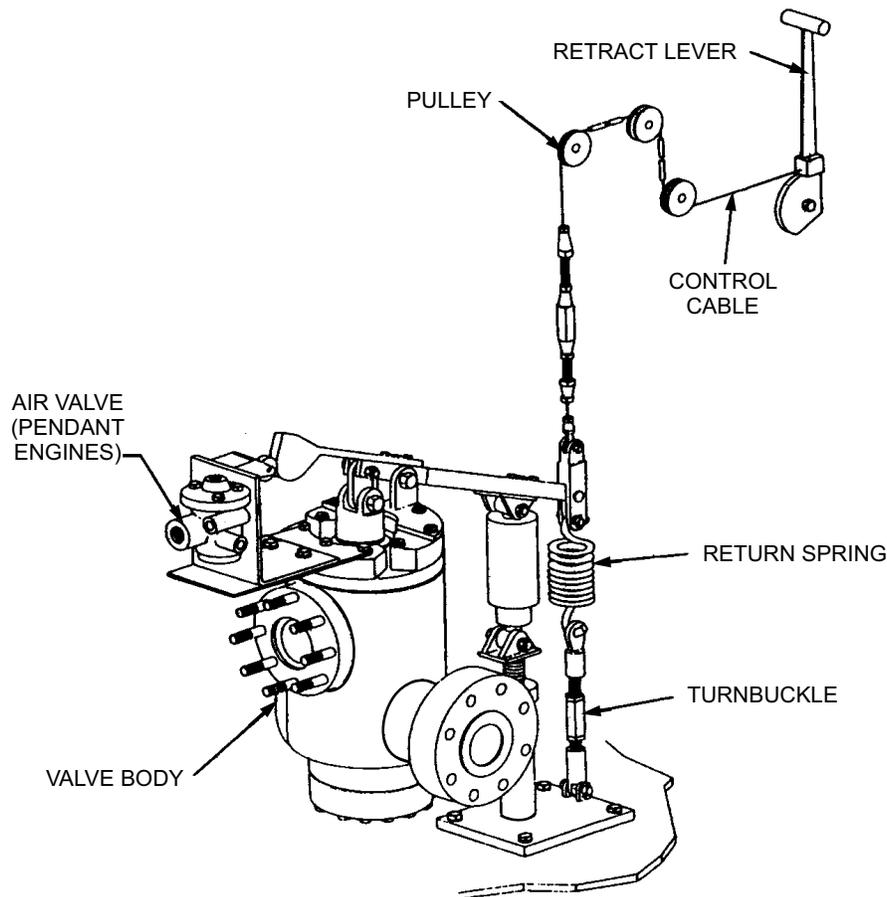
The valve stem is a round piece of machined steel with a shoulder machined midway between the top and bottom. This shoulder mates with the valve seat and blocks fluid flow through the retract valve during arrestment and from the accumulator to the engine cylinder until retraction is desired.

### Plunger

The plunger is a round piece of machined steel that is blind bored at one end to receive the shank of the valve stem. The plunger and valve stem are connected by a dowel pin. The opposite end of the plunger has a machined clevis and is externally threaded just below the clevis. The threaded portion is for an adjusting nut and a locknut used to adjust the stroke of the plunger and valve stem. The stroke is adjusted to 0.678 (11/16) of an inch. The clevis connects the operating lever and the plunger. The opposite end of the operating lever is connected to a tie rod, a return spring, and a control cable by another clevis. The control cable is attached to the T-shaped retracting handle at the deckedge control station. See figure 3-7.

### RETRACTING LEVER

There is a retracting lever (fig. 3-8) for each arresting engine located at the deckedge control station. The retracting lever provides a remote means of opening the retracting valve from a location where the operator will have full visibility of recovery operations.



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Figure 3-8.—Retracting valve and controls.

When the operator pulls down on the retracting lever, the force transmitted through the control cable lifts the end of the retracting lever that is attached to the return spring and tie rod. The retracting lever has a pivot point on the block mounting of the valve. As the one end of the retracting lever is lifted, the end connected to the plunger pushes down on the plunger and valve stem, allowing fluid flow through the valve from the accumulator or fluid cooler to the engine cylinder, thus forcing the ram and crosshead back to their battery position. After retraction is complete, the retracting lever is released and the return spring pulls down on the retracting lever, which in turn pulls up on the plunger and valve stem, which closes the valve. See figure 3-7.

The ideal condition is that tension be kept on the purchase cable from the beginning of the retracting stroke until the ram is in its battery position. An interruption of the stroke generally disrupts this condition and creates cable backlash, which results in cable slack on the engine.

If an emergency arises involving the safety of personnel or equipment, and an interruption of full-speed retraction is necessary, the following procedures are recommended to prevent possible damage, such as a tight kink, to the purchase cable:

1. Resume retracting very slowly at first to rid the cable system of slack.
2. Resume full-speed retraction only after the cable slack has been eliminated and the cable has tension.

3. Inspect sheave damper sheaves for proper seating of the purchase cable on completion of retraction.

A shock absorber like the one found on automobiles is installed on the operating lever to eliminate chattering of the retracting valve during closing.

## ACCUMULATOR SYSTEM

**LEARNING OBJECTIVE:** Describe the accumulator system.

The Mk 7 Mod 3 arresting engine has a recirculating-type hydraulic system. During arrestment, the hydraulic fluid is forced from the main engine cylinder, through the CRO valve, to the accumulator. An initial air charge of 400 psi in the accumulator builds up to approximately 650 psi during arrestment. This increased pressure is used to force the fluid from the accumulator into the fluid cooler, thus forcing fluid from the previous arrestment, already cooled by the cooler, out of the cooler, through the retracting valve, and into the main engine cylinder, returning the engine to its BATTERY position.

The accumulator (fig. 3-9) is a long, steel cylinder mounted horizontally in saddles on the engine structure, with the fluid end toward the fixed sheaves. Inside the accumulator is a floating piston that separates the air side of the accumulator from the fluid side. The air end of the accumulator is flanged and

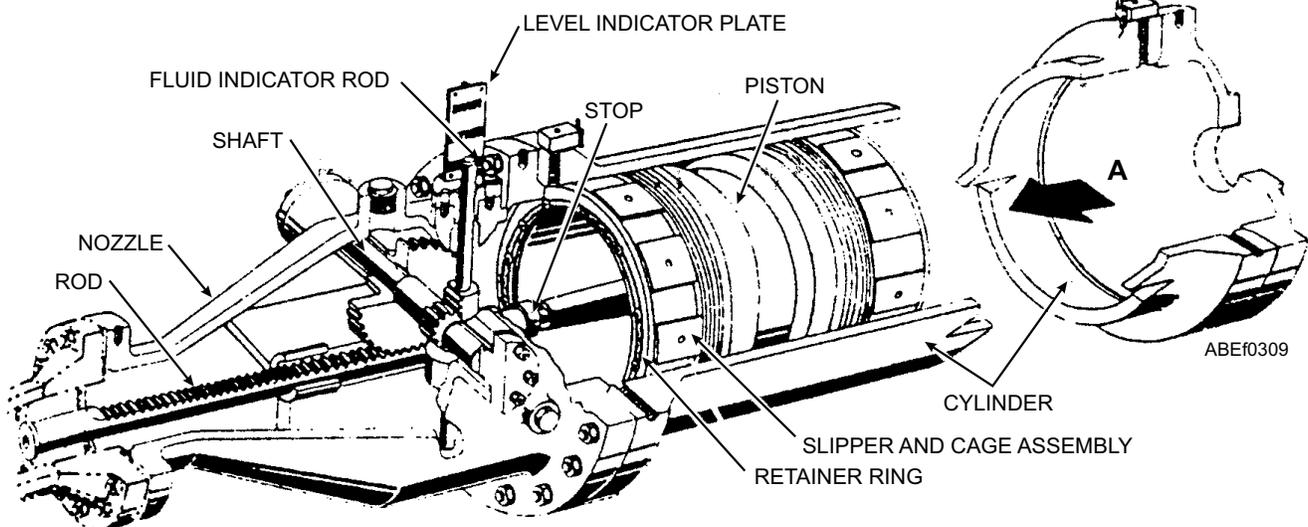


Figure 3-9.—The Mk 7 accumulator.

bolted to the air expansion flask manifold. The fluid end of the accumulator is flanged and bolted to the accumulator nozzle, which contains a fluid-level indicator, a device used to indicate to the engine-room operator whether the system has the proper amount of fluid. The fluid indicator registers the following three conditions—DRAIN (excessive amount of fluid in the system), BATTERY (proper amount of fluid in the system), and FILL (insufficient amount of fluid in the system).

The floating air-fluid separator piston is made of aluminum alloy and has two sets of V-ring packing (one for the air side and one for the fluid side), which prevent air from leaking past the piston into the fluid side of the accumulator, or fluid from leaking into the air side. Two slipper cages with phenolic slippers are fitted onto the piston to act as a bearing surface between the piston and the cylinder wall. The phenolic slippers are replaceable and must be replaced when the maximum allowable wear has been reached. This is to prevent metal-to-metal wear between the piston and the accumulator wall. An eyebolt is provided on the air side of the piston to aid in removing the piston from the accumulator when maintenance is required. The fluid side of the piston has a striker rod that actuates a fluid-level indicator located in the accumulator nozzle.

The fluid-level indicator has a drive shaft that extends through the nozzle from side to side and is secured in place by flanges and bolts. O-rings provide a seal against leakage of fluid around the drive shaft. Gears are secured onto the shaft inside the nozzle. These gears mate with teeth on the actuator rod, which extends fore and aft in the nozzle, and the fluid-indicator rod, which is vertical and extends through the top of the nozzle. An O-ring prevents leakage around the indicator rod. When the striker rod on the piston makes contact with the actuator rod, the drive shaft rotates, causing the indicator rod to move down. See figure 3-9.

An indicator plate is mounted on top of the nozzle. The plate has the readings DRAIN, BATTERY, and FILL. The indicator rod is a differential rod; and any time the piston striker rod is not in contact with the actuator rod, accumulator pressure working on the differential area of the indicator rod will cause the indicator rod to rise to the DRAIN position. The engine crosshead must always be in its BATTERY position when the fluid level of the arresting engine is checked.

## FLUID REPLENISHMENT SYSTEM

**LEARNING OBJECTIVE:** Describe the components of the fluid replenishment system.

In any hydraulic system, small amounts of fluid are lost due to leakage. Fluid also contracts when cold and expands when hot. To compensate for leakage and expansion or contraction of the hydraulic fluid in the hydraulic system of the Mk 7 arresting engines, a fluid replenishment system is provided. See figure 3-10.

The fluid replenishment system consists of a small hand pump, mounted on the lower engine frame that is connected by piping to the engine accumulator and a 6-gallon stowage tank. If, because of leakage or fluid contraction while the engine crosshead is in BATTERY, the fluid-level indicator reads FILL, the supply valve in the piping is opened and the hand pump is operated until the indicator reads BATTERY. A fluid filter is located in the supply line to filter the fluid being pumped into the accumulator. If the fluid-level indicator reads DRAIN, the return valve located in the return line is opened, and fluid from the accumulator drains into the replenishment tank. When the fluid-level indicator reads BATTERY, the return valve is closed.

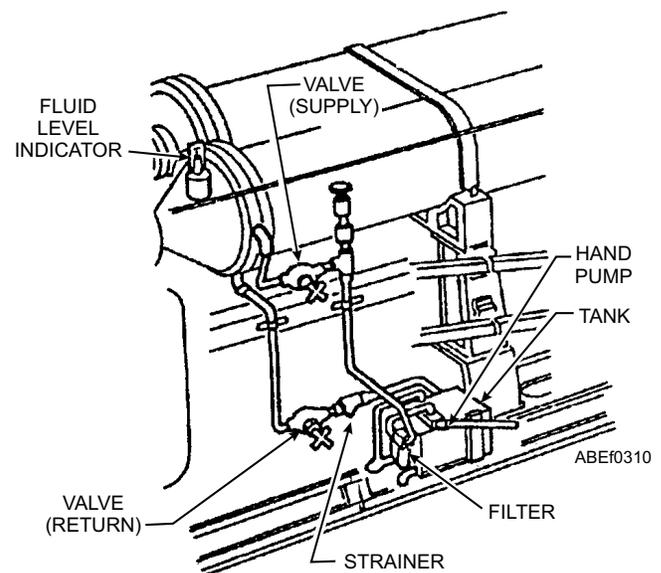


Figure 3-10.—Fluid replenishment system.

## FLUID STOWAGE SYSTEM

A fluid stowage system (fig. 3-11) is provided to stow fluid from the arresting engine during maintenance and to transfer fluid back to the engine after maintenance is complete. The fluid stowage system consists of one common, steel stowage tank that serves all the arresting engines installed on a particular ship. It is equipped with piping valves from the accumulator to the stowage tank.

The capacity of the fluid stowage tanks is 700 gallons. The stowage tank is capable of storing all the fluid in the system of one arresting engine. Ship's low-pressure air is used to force the fluid to and from the stowage tank. A pressure relief valve, which is set at 120 psi, is provided to prevent excessive pressure buildup. The relief valve is located on the stowage tank. In addition, a 90-gallon stowage tank is installed on each side for the port and starboard sheave damper assemblies. The 90-gallon stowage tank is a repository to transfer and replenish hydraulic fluid for the sheave damper assemblies.

## FLUID RECLAMATION SYSTEM

The fluid reclamation system (fig. 3-12) provides a means of reclaiming hydraulic fluid removed from any engine due to venting or through leaks or spills. The

fluid reclamation system consists of a stainless steel 90-gallon tank located in close proximity to the fluid stowage tank, a centrifugal 1/3 hp pump, filter and piping connections. The piping connects the reclamation tank to the existing stowage tank line. During fluid transfer from the reclamation system, hydraulic fluid is filtered to ensure that only clean uncontaminated fluid enters the fluid stowage tank.

## FLUID COOLER

During continuous arresting operations, the engine fluid temperature rises because of friction of the fluid moving through the engine, control valve, and piping. To maintain extended pendant engine operation, the fluid temperature is reduced by the fluid cooler. (See fig. 3-13.) The maximum operating temperature for the arresting engines is 170°F. Prolonged operation at this temperature limit is not recommended.

The fluid cooler is mounted in saddles on top of the engine structure adjacent to the accumulator.

Fluid coolers are used on all Mk 7 arresting engines serving a pendant engine. Engine fluid, as it is returned from the accumulator to the main engine cylinder during retraction of the engine, flows through the fluid cooler body. Heat from the engine fluid is transferred to cool service water (salt water) flowing at 100 gallons per minute through tubes within the cooler body.

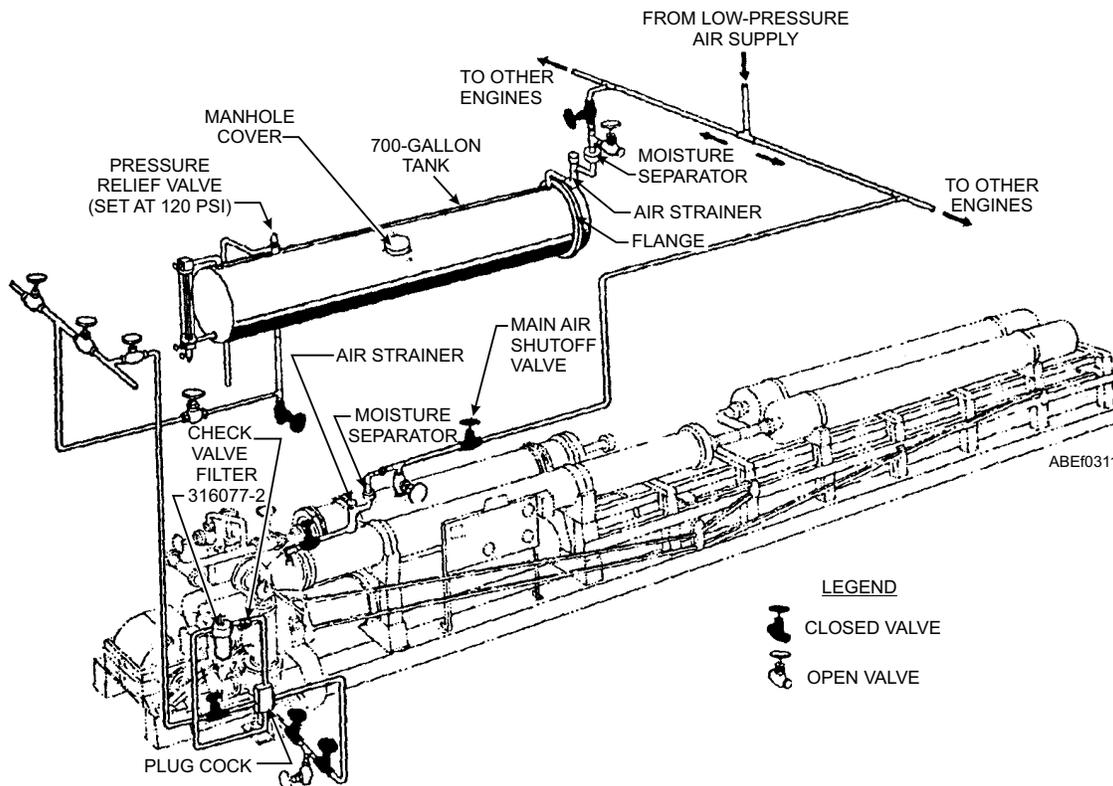
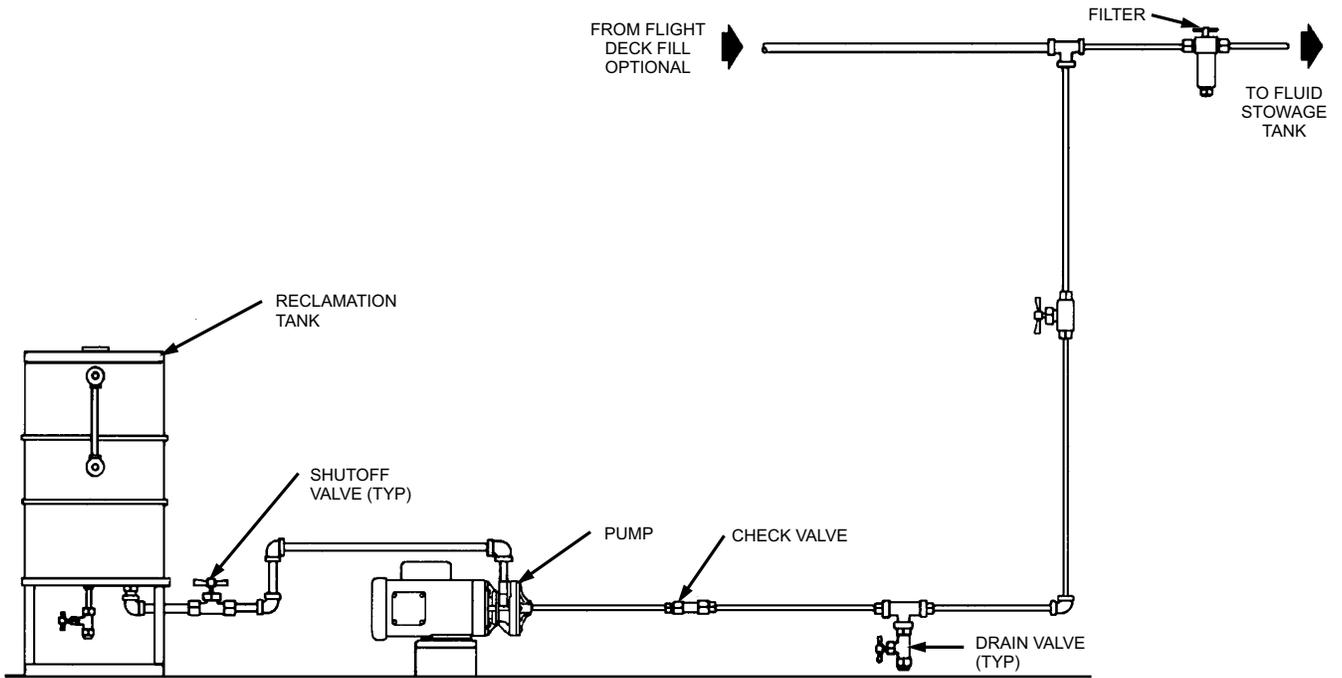
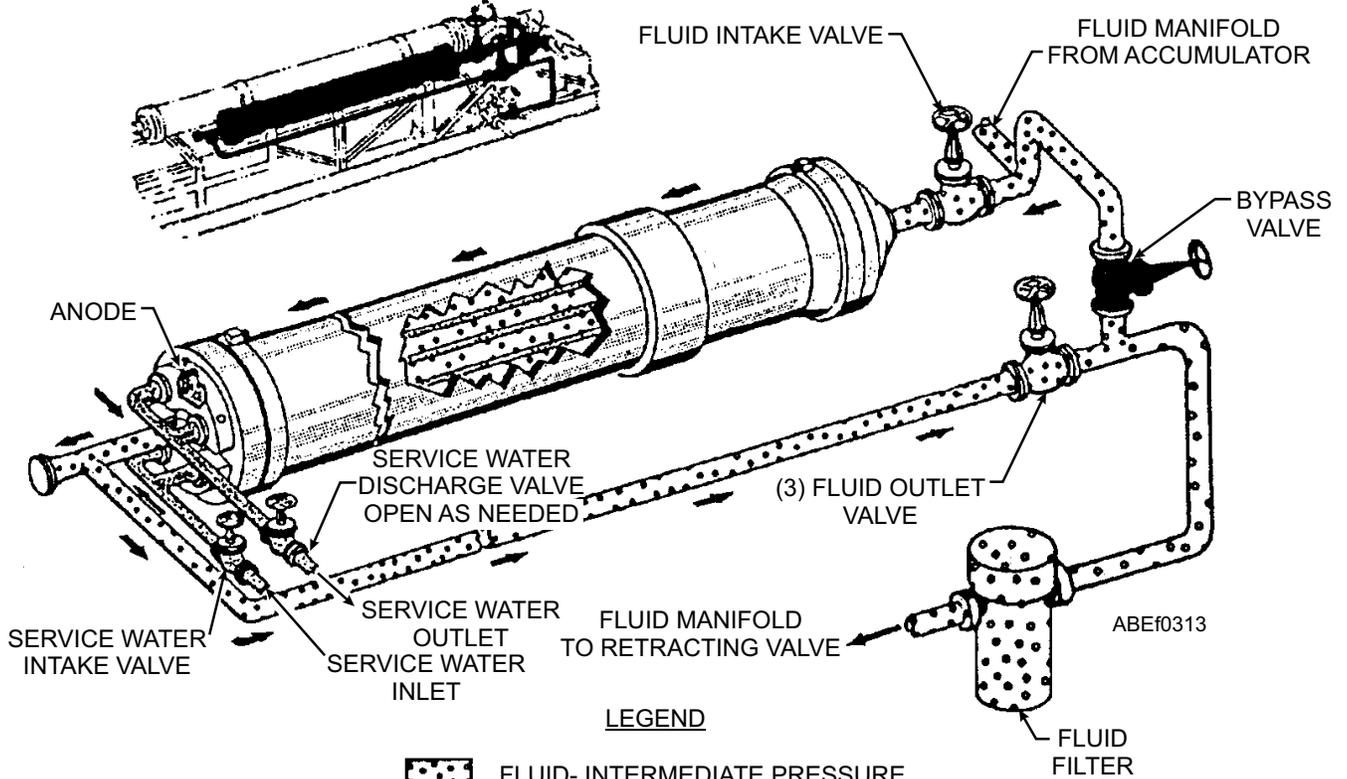


Figure 3-11.—Fluid stowage system—secured condition.



ABE0312

Figure 3-12.—Fluid reclamation system



ABE0313

Figure 3-13.—Fluid cooler assembly.

The fluid cooler body is a cylindrical steel shell with two flanged ends. The body of the cooler has four equally spaced holes in each end to provide a means of draining and venting the cooler. These holes are normally closed with pipe plugs or vent valves. One end of the cooler has a cooler head assembly that forms a cap for one end of the body and provides an inlet for engine fluid coming from the accumulator. The cooler head assembly is a disc-shaped steel casting with an opening in the center, which is flanged to the fluid inlet piping.

A copper annealed gasket is used as a seal between the cooler head and the body to prevent fluid leakage. The head is bolted to the body. The coolant (salt-water) flows through a tube assembly that consists of 107 U-shaped copper tubes supported inside the cooler body by three circular baffle plates. A tube head is bolted to the end of the cooler, opposite of the cooler head. A copper annealed gasket is used as a seal against fluid leakage between the tube head and the cooler body. Cooled fluid passes through the center of the tube head, through piping, to the retract valve. Two kidney-shaped manifolds (one inlet and one outlet manifold for the coolant to flow) are bolted to the outer face of the tube head.

Saltwater piping leading to and from the inlet and outlet manifolds has shutoff valves, one intake and one

discharge, that are used to throttle the flow of salt water and maintain the desired fluid temperature. Shutoff valves are also provided in the fluid inlet and outlet lines to provide a means of isolating the fluid cooler in the event of cooler leakage, and a bypass valve is provided to direct the fluid from the accumulator to the retract valve when the cooler is isolated. To prevent corrosion within the cooler, replaceable anodes are installed at both the saltwater inlet and outlet manifolds. These anodes are periodically inspected and replaced according to the applicable maintenance requirement card (MRC). A fluid temperature indicator is located on the engine control panel.

### AUXILIARY AIR FLASKS

The auxiliary air flask provides a means of storing ship's air at 3,000 psi. In the event of a ship's air system failure, the air stored in the auxiliary air flask can be used to recharge the arresting engine.

The air flask is a cylindrical container with hemispherical ends. One end of the air flask is provided with a pipe tap for connecting an air line, which is used for charging and venting. A drainage vent is located on the underside of the air flask to drain condensate water.

Air can be supplied to the air unit of the arresting engine from the auxiliary air flask by use of the charging valve mounted on the main control panel.

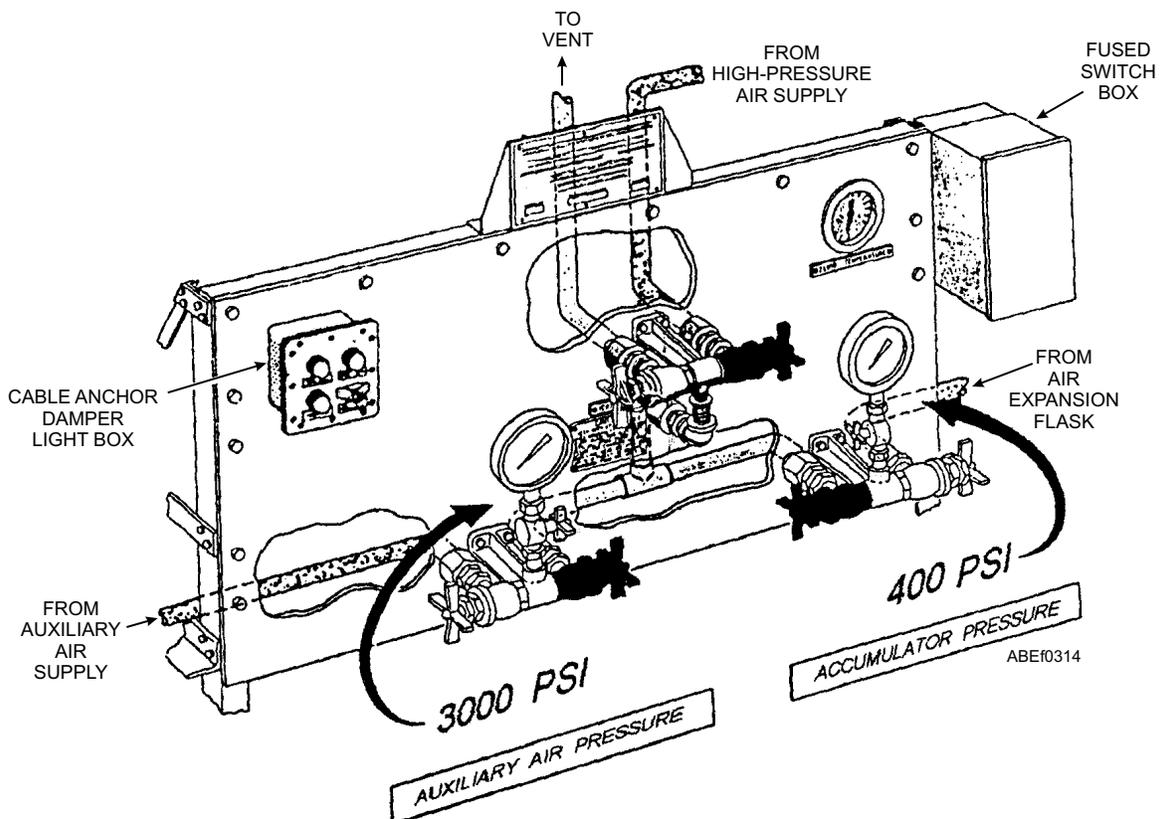


Figure 3-14.—Engine control panel.

## MAIN CONTROL PANEL

The control panel is the control center for the arresting engine. (See fig. 3-14.) It provides a means for the operator to centrally regulate the air pressure in the system, keep a check on the fluid temperature, and energize the electrical system. The control panel is also equipped with a cable anchor damper light box.

The control panel is a rectangular sheet of steel mounted on the engine structure on the CRO-valve side of the engine.

Three air manifolds are located on the control panel: a main air-charging manifold with high-pressure air piping leading from the ship's high-pressure air supply system; an air manifold for the auxiliary air flasks; and a manifold for the accumulator. The main air-charging manifold is equipped with an air-charging valve, which is closed except when taking on air from the ship's high-pressure air supply system to charge the auxiliary air flasks and accumulator.

High-pressure air piping is provided from the main air-charging manifold to the auxiliary air flask manifold and the accumulator manifold. The auxiliary air flask and accumulator manifolds each have

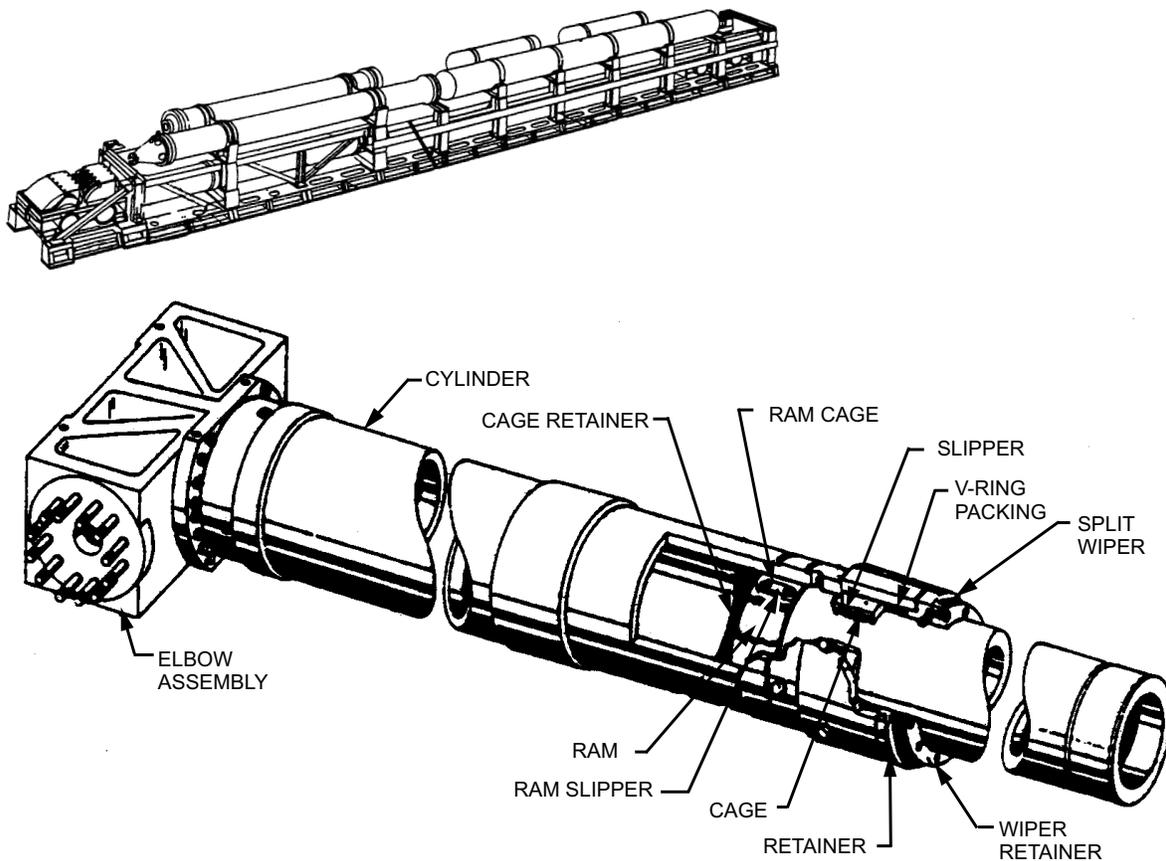
air-charging valves, gauge valves, and a pressure gauge. The auxiliary air flask charging valve allows for charging the auxiliary air flasks or emergency charging of the accumulator from the air flasks. The auxiliary air flask pressure gauge monitors the air pressure of the auxiliary air flasks. The accumulator charging valve allows for charging of the accumulator and air expansion flask. The accumulator pressure gauge monitors the air pressure of the accumulator and air expansion flask.

A fuse switch box is mounted at the end of the control panel and contains the main switches for activating the electrical system of the arresting gear.

The cable anchor damper battery position indicator light box on the control panel contains a power ON and OFF switch and three indicator lights. A white light indicates the power switch is on. Two green lights give battery position indication of the cable anchor dampers.

## CYLINDER AND RAM ASSEMBLIES

The cylinder acts as a receiver for the ram and as a reservoir for the fluid to be displaced by the ram. Figure 3-15 illustrates the cylinder and ram assembly of the Mod 3 arresting engine.



ABEf0315

Figure 3-15.—Cylinder and ram assembly.

The cylinder and ram assembly constitutes the actual engine of the arresting gear. It is located within the engine structure between the movable crosshead and the cylinder outlet elbow on the engines.

The cylinder is a machined, forged steel, smooth-bore tube, open on both ends and large enough to provide a working area for the ram and to house the fluid necessary for aircraft arrestments. It is supported within the engine structure by cylinder support saddles. One end of the cylinder is clamped and bolted with four cylinder clamps and Allen bolts to the cylinder outlet elbow. The other end receives the ram

The ram is a large, hollow steel piston that is moved in and out of the cylinder by the crosshead. It is bored to reduce the weight, although it is not bored completely through. The inner end (the end that fits in the mouth of the cylinder) is solid and provides a working area between the ram and engine fluid during arrestments.

The inner end of the ram contains a set of V-ring packing to provide a seal for the engine fluid between the cylinder wall and the ram also the inner end of the ram is stepped to accommodate a cage and slippers, which provide a bearing surface for the ram as it slides in and out of the cylinder.

The outer (open) end of the hollow steel ram is clamped into a socket on the crosshead by a split flange, which fits into an annular groove near the end of the ram.

### CROSSHEAD AND FIXED SHEAVE INSTALLATION

The principle involved in the operation of the crosshead and fixed sheaves is that of a block and tackle. The purchase cables are reeved around the sheaves of the crosshead and fixed sheave assemblies. The crosshead is a three-piece welded structure with two hollow steel shafts clamped between its outer sections and the center section. The crosshead body is clamped to the outer end of the ram by a split flange, which fits into an annular groove around the end of the ram. Figure 3-16 illustrates the crosshead.

The crosshead contains two similar banks of sheaves, with nine sheaves in each bank. The sheaves located outboard on the crosshead are 33-inch pitch diameter, and the sheaves located on the inboard shaft are 28-inch pitch diameter. The difference in the pitch diameter of the two banks of sheaves is necessary so that the purchase cable reeved around the outboard

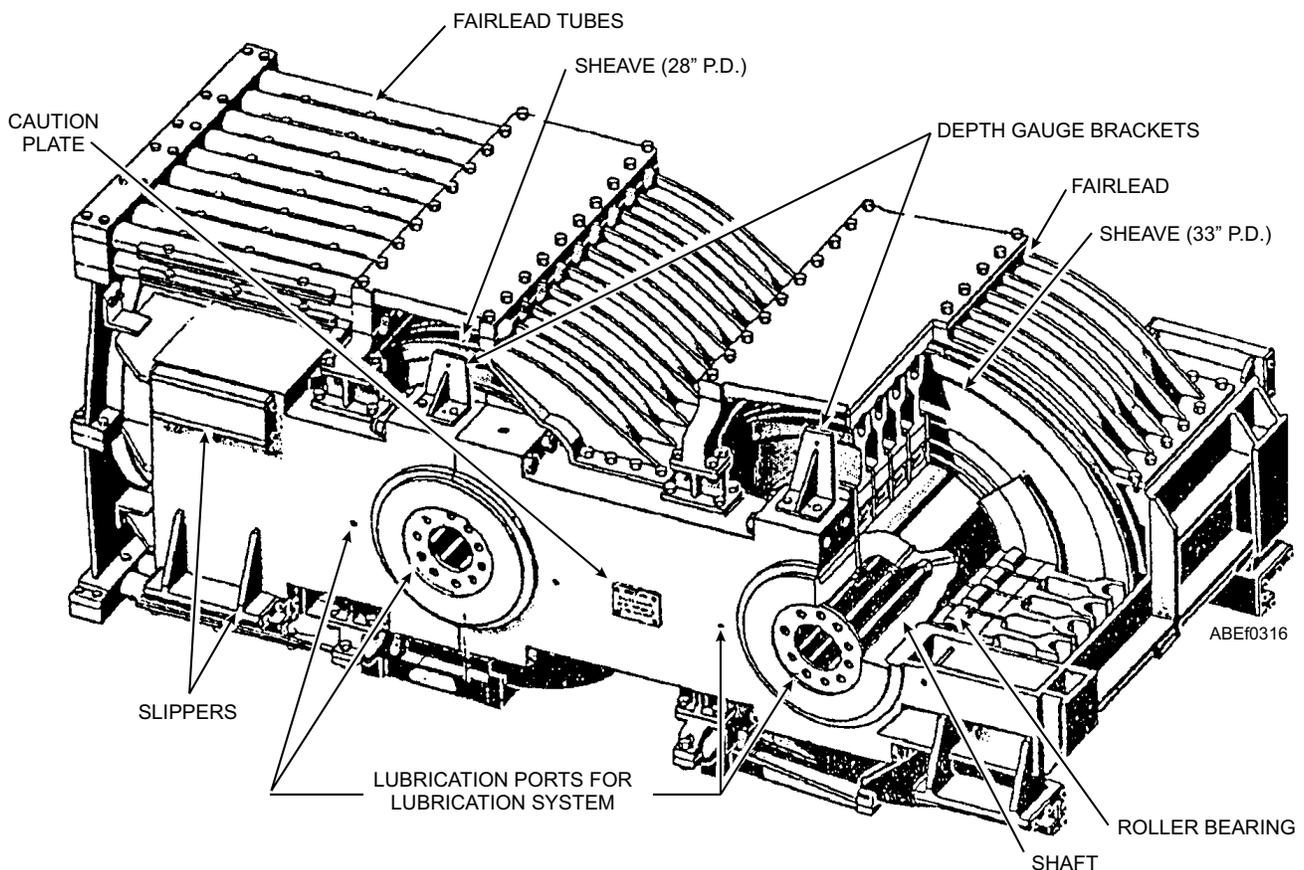


Figure 3-16.—Crosshead assembly.

(33-inch pitch diameter) sheaves will clear the inboard (28-inch pitch diameter) sheaves.

The crosshead sheaves are made of an aluminum alloy casting and have three sections: an inner race, a cage and roller assembly, and an outer race. All the sheaves in the crosshead and the fixed sheave installation rotate on roller bearings with the exception of the 28-inch pitch diameter high-speed sheave that fairleads the purchase cable from the engine to the flight deck. This sheave rotates on a ball thrust bearing. The sheaves are separated by two-section concentric disc spacers. Each spacer has an inner and an outer disc. The inner disc is made of steel and provides lubrication channels from the shaft to each cage roller assembly. The outer disc is made of phenolic and acts as a bearing surface for the outer sheave race; it also retains the grease.

Phenolic spacers are bonded to the sheaves on the high-speed side only. The low-speed side has loose

phenolic spacers. The sheaves are lubricated through 10 zerk fittings located on the end of each of the two hollow steel shafts (20 zerks total).

The crosshead is provided with slipper liners as a bearing surface between the crosshead and the crosshead tracks. There is a total of 16 slipper liners—2 on each side at the top, to prevent side thrust, and 3 on each corner at the bottom, for a bearing surface. Brass retainers hold the slipper liners in place.

The fixed sheave assembly is identical in construction to the crosshead, and all movable parts are interchangeable. The fixed sheave assembly acts as the stationary half of the reeve system and therefore does not require liners. See figure 3-17.

### AUTOMATIC LUBRICATION SYSTEM

**LEARNING OBJECTIVE:** Describe the automatic lubrication system.

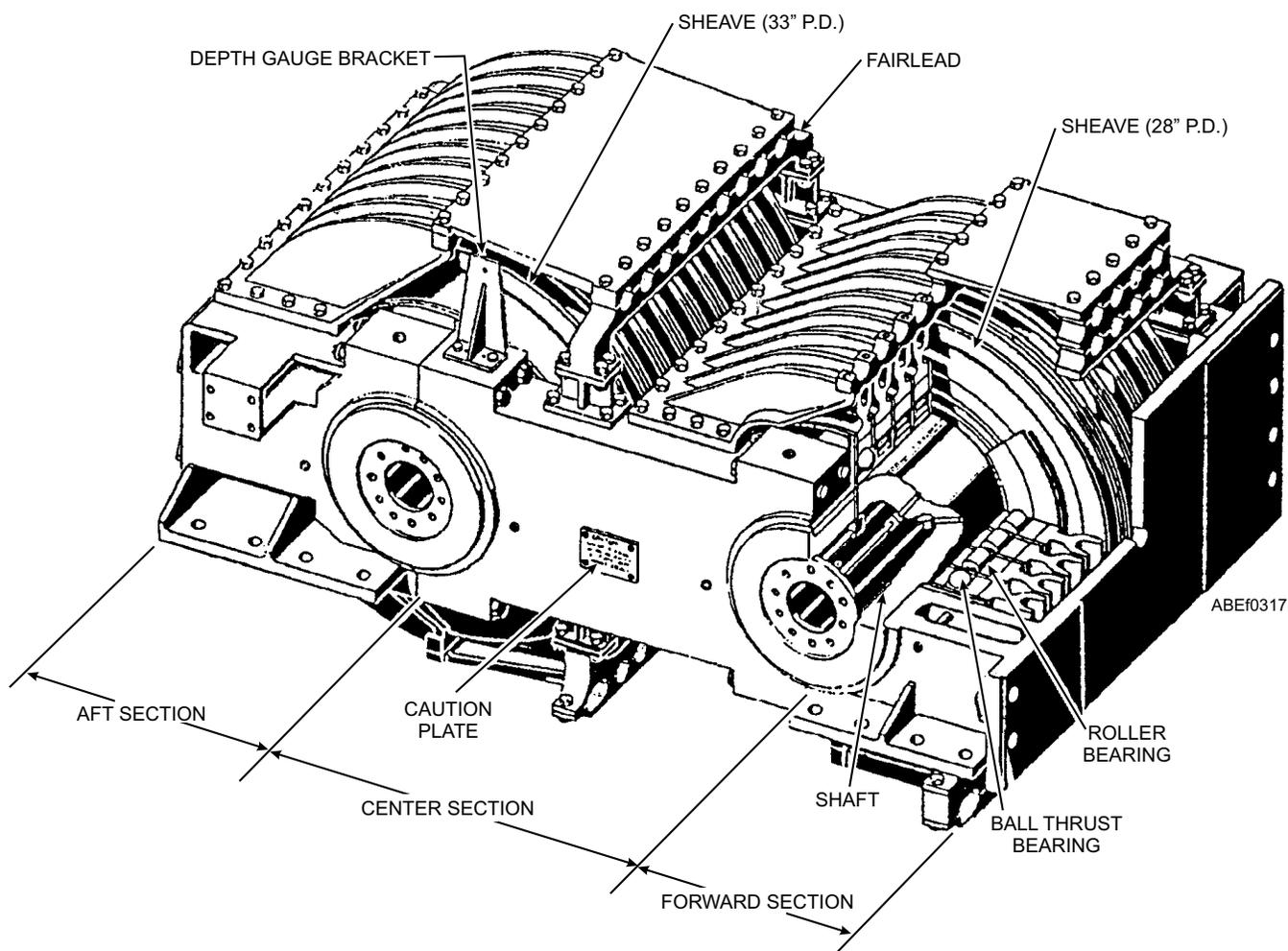


Figure 3-17.—Fixed sheave assembly.

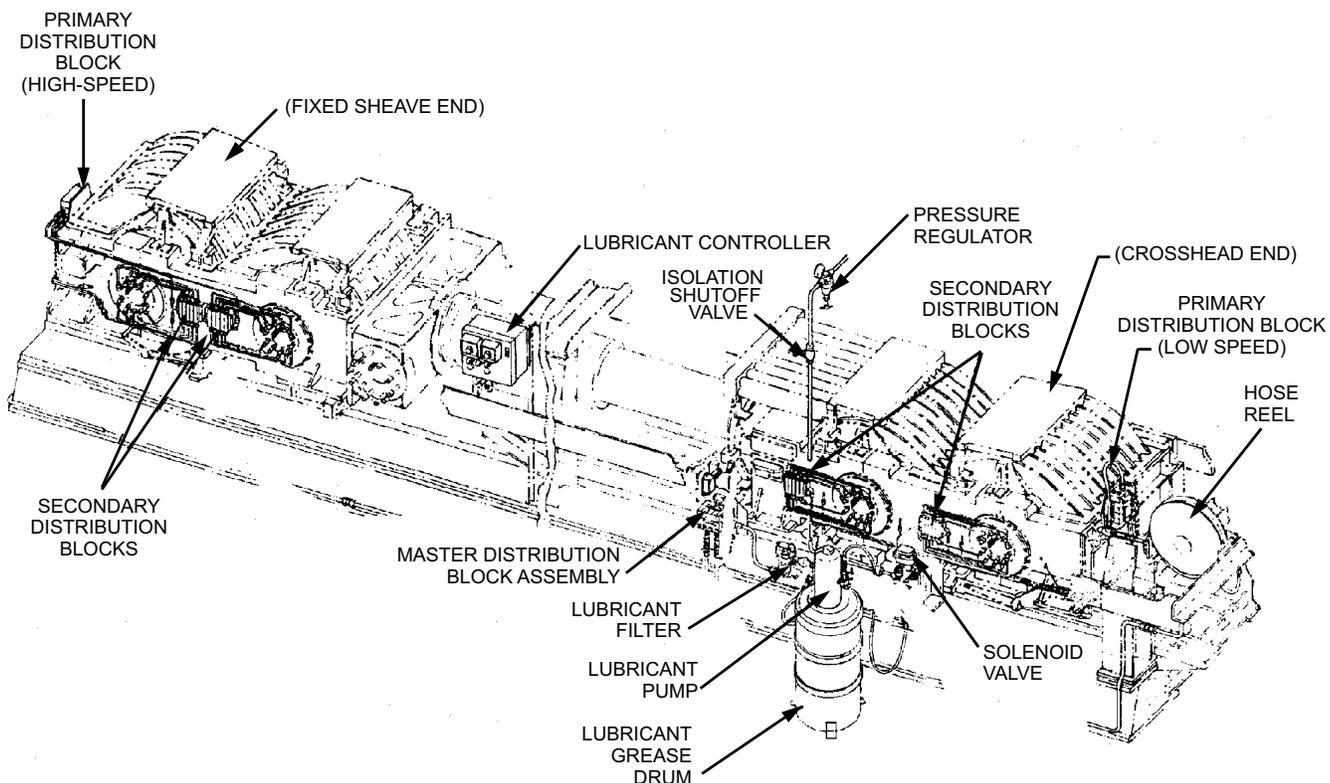
An automatic lubrication system (fig. 3-18) ensures that lubricant is automatically provided to the arresting engine crosshead and fixed sheave assembly during arrestment operations (pendant engines only). The ship's low-pressure air, is piped to a regulator, which reduces the air to the required operating pressure of between 75 and 85 psi. Air is fed through a rubber hose to a pump mounted on top of a 120-pound drum of lubricant. Lubricant is pumped from the drum through hoses to control valves mounted on the engine structure. These control valves adjust the rate of flow of lubricant to the high-speed sheaves.

The control valves are operated by plunger rollers, which are cam-actuated at a set position of the engine crosshead arrestment stroke. An ounce of lubricant is pumped to the high-speed sheaves during the arrestment and the retraction cycles. A hose reel with a flexible rubber hose is mounted on the crosshead end of the engine structure, with the hose connected to metal tubing on the engine crosshead. As the crosshead moves toward the fixed sheaves during arrestment, the hose pays out and spring tension in the hose reel takes

up the hose during retraction. The spring tension on the hose reel must be 9 pounds ( $\pm 1/2$  pound), with the hose fully retracted, at all times.

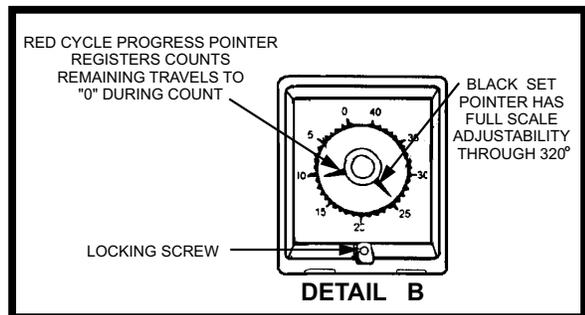
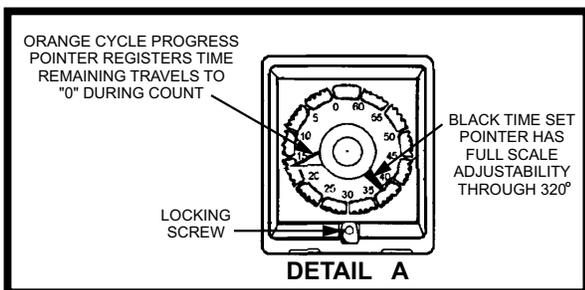
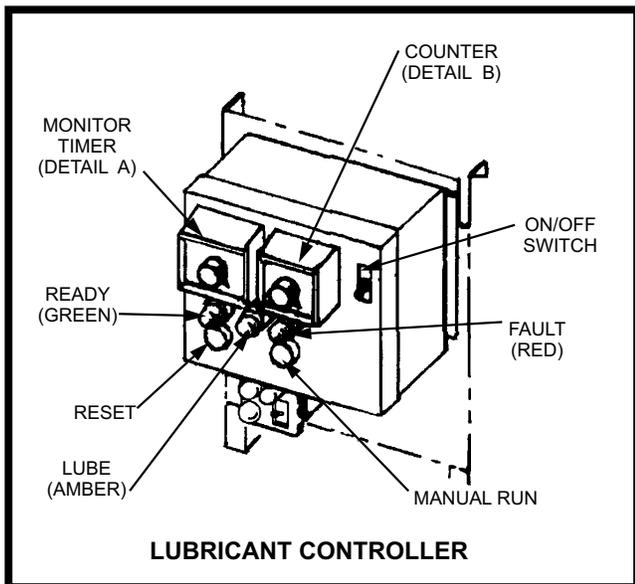
The automatic lubrication controller (fig. 3-19) allows the engine room operator to set both a pulse counter and a timer unit which deliver a predetermined amount of lubricant to every lubrication point. The controller signals when the system is ready, when it is operation or when a malfunction occurs. The controller can be operated manually to initiate a lubrication cycle without movement of the crosshead and cal reset itself after a malfunction has been corrected in the lubrication system.

The 28-inch pitch diameter sheave containing the ball thrust bearing is not lubricated with the automatic lubricating system. The ball thrust bearing eliminates the need for constant lubrication. Lubricating the ball thrust bearing sheave is accomplished with a manually operated grease gun after every 20 to 30 arrestments. (See fig. 3-18 for an illustration of the automatic lubrication system.)



ABEf0318

Figure 3-18.—Automatic lubrication system.



ABEF0319

Figure 3-19.—Automatic lubrication controller.

## CABLE ANCHOR DAMPER

**LEARNING OBJECTIVE:** Describe the components of the cable anchor damper.

The cable anchor damper installation consists of two identical anchor damper assemblies. In most cases one cable anchor damper assembly is deck mounted

and the second assembly is overhead mounted (fig. 3-20). Compartment configuration determines how the units are installed.

The purpose of the cable anchor damper is to eliminate excessive purchase cable slack between the crosshead and fixed sheave assembly at the beginning of the arrestment stroke. Through service use and experimental testing, it was found that when this cable slack was taken up by the landing aircraft, excessive vibrations occurred in the engines. The cable anchor damper removes this slack as it occurs, thereby eliminating vibration of the purchase cable. The cable anchor damper assembly is used with pendant engines only.

Referring to figure 3-20, note that each cable anchor damper assembly includes a cylinder that connects to an operating end head and a cushioning end head. Piping connects the engine cylinder to the operating end head through a manifold tee. Two lines branch from the manifold tee, one to each damper assembly operating head. Each of these lines contains a flow control valve. A cover is placed over the operating piston rod and coupling assembly for safety of operation and protection against foreign matter. Each damper assembly is mounted on a base before installation.

A battery positioner, actuated by the retracting lever, is provided to ensure the return of the damper assembly to the BATTERY position after an arrestment. A battery-position indicator is provided to indicate when the cable anchor damper is in the BATTERY position, ready for aircraft engagement. The limit switch and cam actuator for the battery-position indicator are located on the cable anchor damper assembly, and the indicator lights are located on the arresting engine control panel.

The end of the purchase cable is attached to the operating end piston rod by an anchor damper coupling. When the force on the operating piston, due to engine cylinder pressure, is greater than the tensile force in the purchase cable, the piston moves away from its BATTERY position. Movement of the operating piston into the cylinder removes the cable slack during the first portion of the arrestment. When the slack is taken up, the operating piston resists the return of the cable, thus keeping it taut and preventing excessive cable vibration.

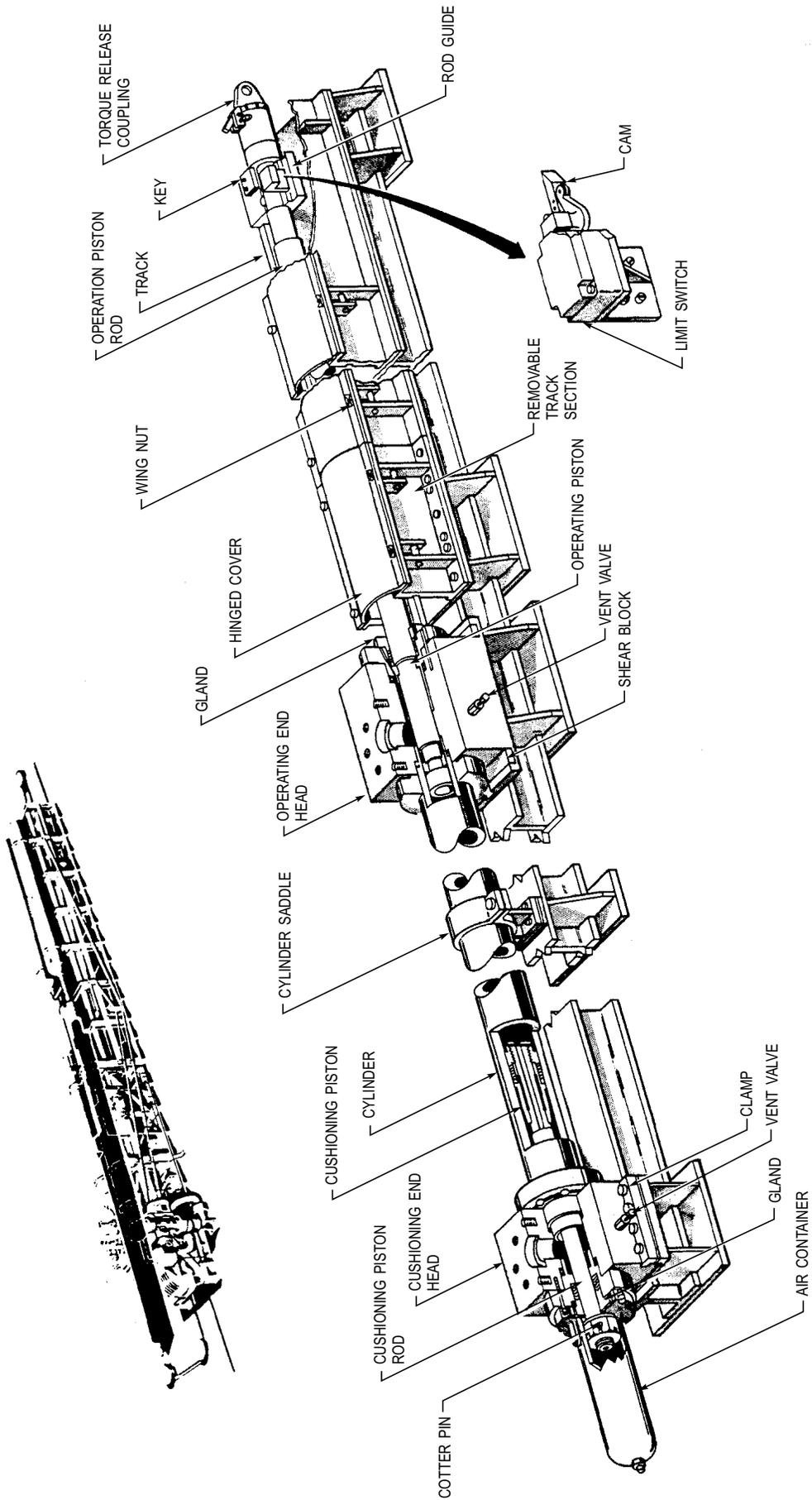


Figure 3-20.—Cable anchor damper installation.

ABE0320

Upon engagement of the deck pendant by the aircraft, the engine crosshead is accelerated toward the fixed sheaves. This movement forces the ram into the arresting engine cylinder, increasing the fluid pressure in both the engine cylinder and the operating head of each cable anchor damper. See figure 3-21.

Because of the acceleration rate of the engine crosshead, the tension in the purchase cable (2) between the engine sheaves and the cable anchor dampers decreases momentarily. The instant the tensile force in the cable becomes less than the force on the operating piston (4), fluid pressure moves the operating piston away from its BATTERY position until all slack is removed and the cable tension is again greater than the fluid pressure force acting on the operating piston.

The flow control valve is a clapper-type check valve that allows free flow of the fluid one way and a restricted flow in the opposite direction. The engine fluid has free flow through the flow control valve (1) to

the operating end of each cable anchor damper. When the tension of the purchase cable is transmitted to the cable anchor ends, the fluid pressure on the operating pistons is overcome by this cable tension, and the operating pistons are pulled back toward BATTERY position. Resistance to their return is furnished by the engine fluid pressure and the controlled flow of fluid through the flow control valves back to the engine cylinder.

### CUSHIONING PISTON

The sole function of the cushioning piston is to prevent the operating piston from slamming into the opposite end of the cable anchor damper assembly if the purchase cable should break or in the event of an extreme off-center landing. In either situation, the operating piston accelerates away from its BATTERY position and rams the cushioning piston.

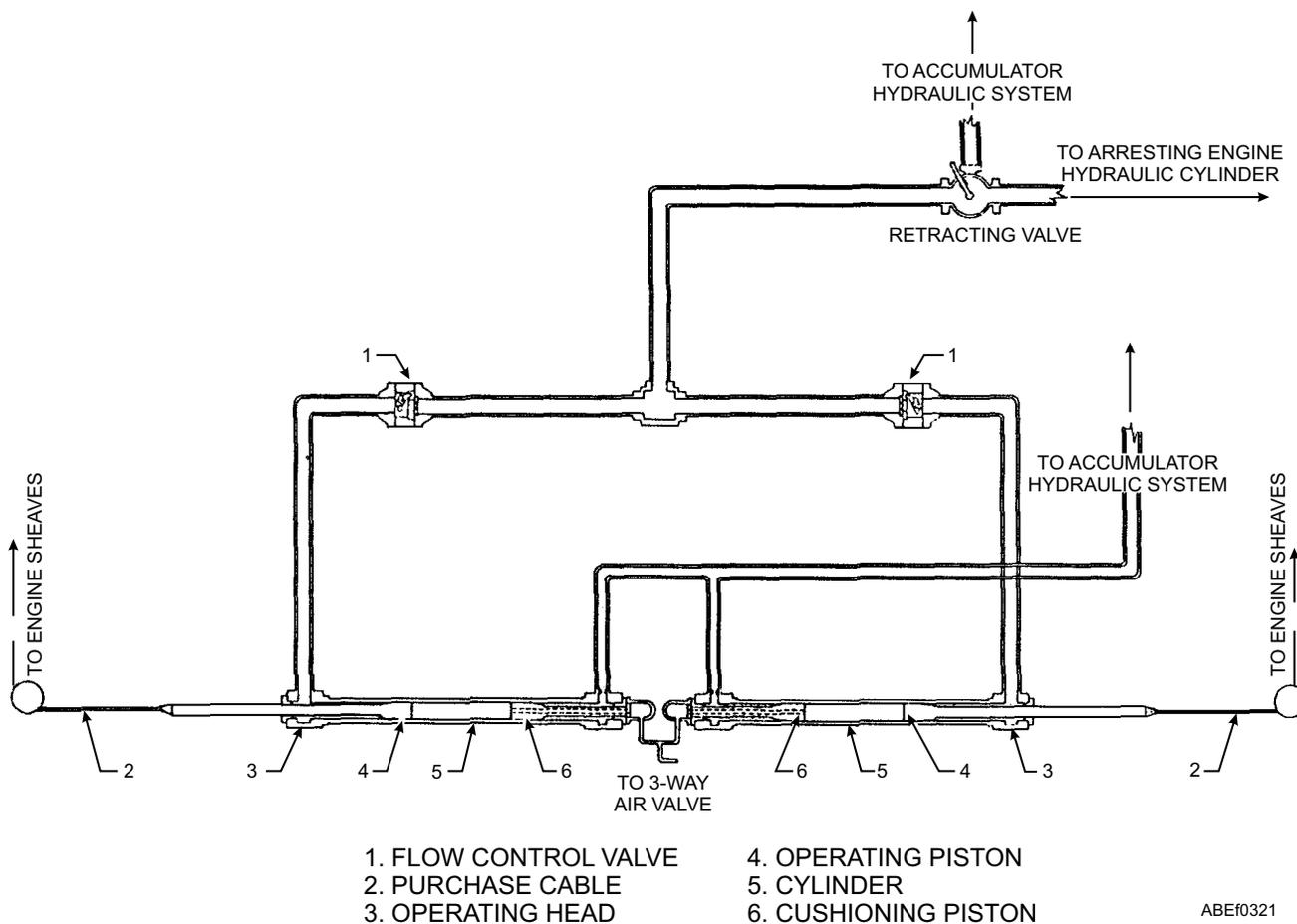


Figure 3-21.—Cable anchor damper fluid flow (arrestment).

## BATTERY POSITIONER

The battery positioner (fig. 3-22) functions to return the cable anchor damper piston to its BATTERY position during the retracting cycle of the arresting engine.

The battery positioner includes a three-way air valve (3), which is connected to a 100-psi air supply and to the air container mounted on the cushioning end of each damper assembly. An air strainer (4) is located in the supply line ahead of the three-way valve. The three-way air valve is mounted on a base plate (5), secured to the arresting engine retracting valve, and operated by means of a cam (1) mounted on the retracting valve actuating lever.

When the actuating lever is moved to its retract position, the cam positions the three-way air valve to admit 100-psi air to the air containers. From the air container, the 100-psi air passes through a hole in the cushioning piston rod and acts against the operating piston, moving it to its fully retracted position. As soon as the actuating lever is released, the air pressure is shut off, and the air container is vented through an exhaust line (2) at the three-way air valve. A line containing a liquid sight indicator (7) and a drain plug (6) is provided at each container. The fluid sight indicator permits detection of fluid leakage into the air container.

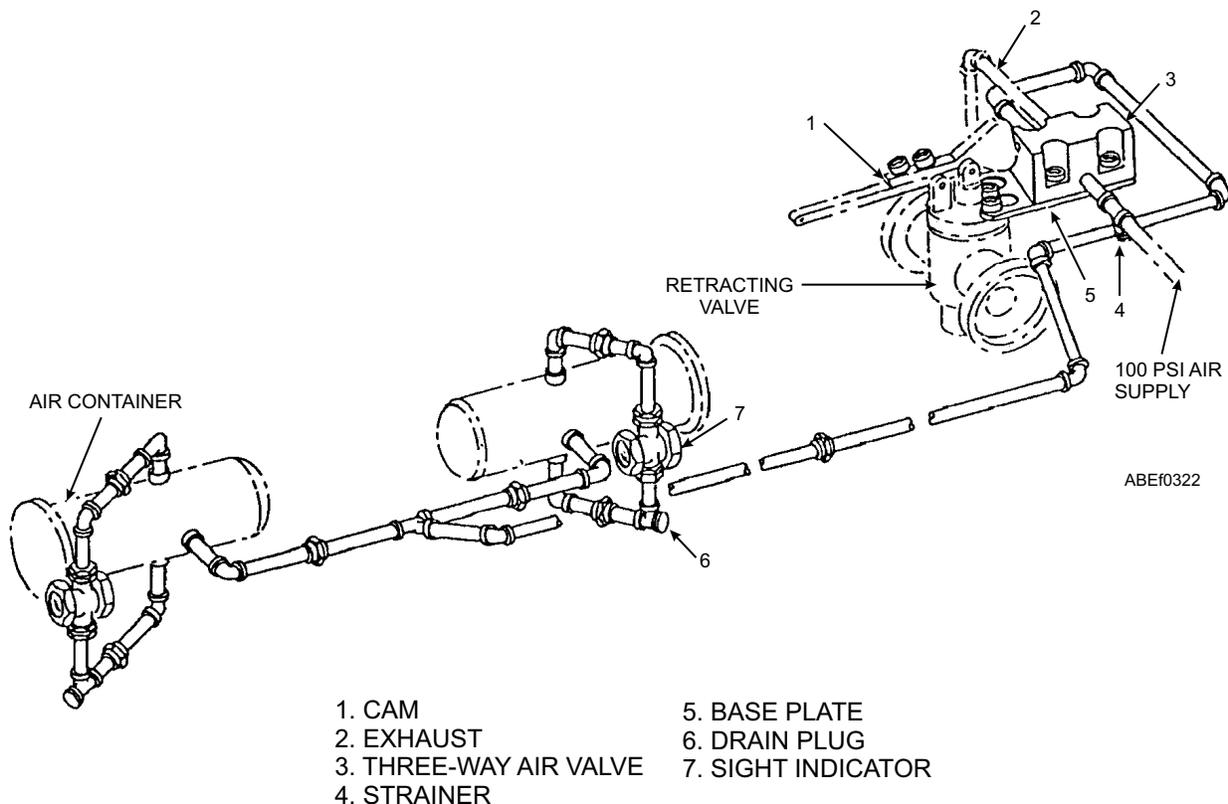


Figure 3-22.—Battery positioner.

## ARRESTING ENGINE DRIVE SYSTEM

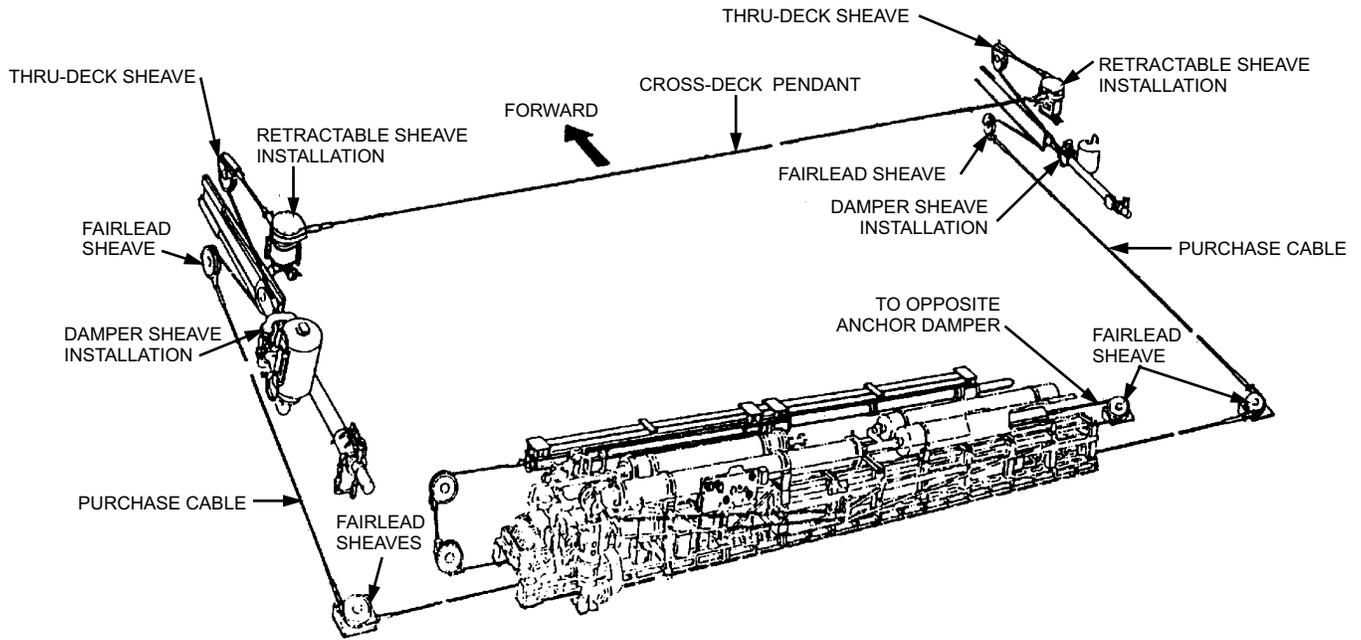
**LEARNING OBJECTIVE:** Describe the components of the arresting engine drive system.

The function of the drive system is to provide a means of transferring energy from an arresting aircraft to the arresting engine components that provide the means of dissipating and absorbing that energy. The drive system consists essentially of sheave damper, purchase cable, fairlead and deck sheaves, crossdeck pendants, and wire supports (fig. 3-23).

### SHEAVE DAMPER

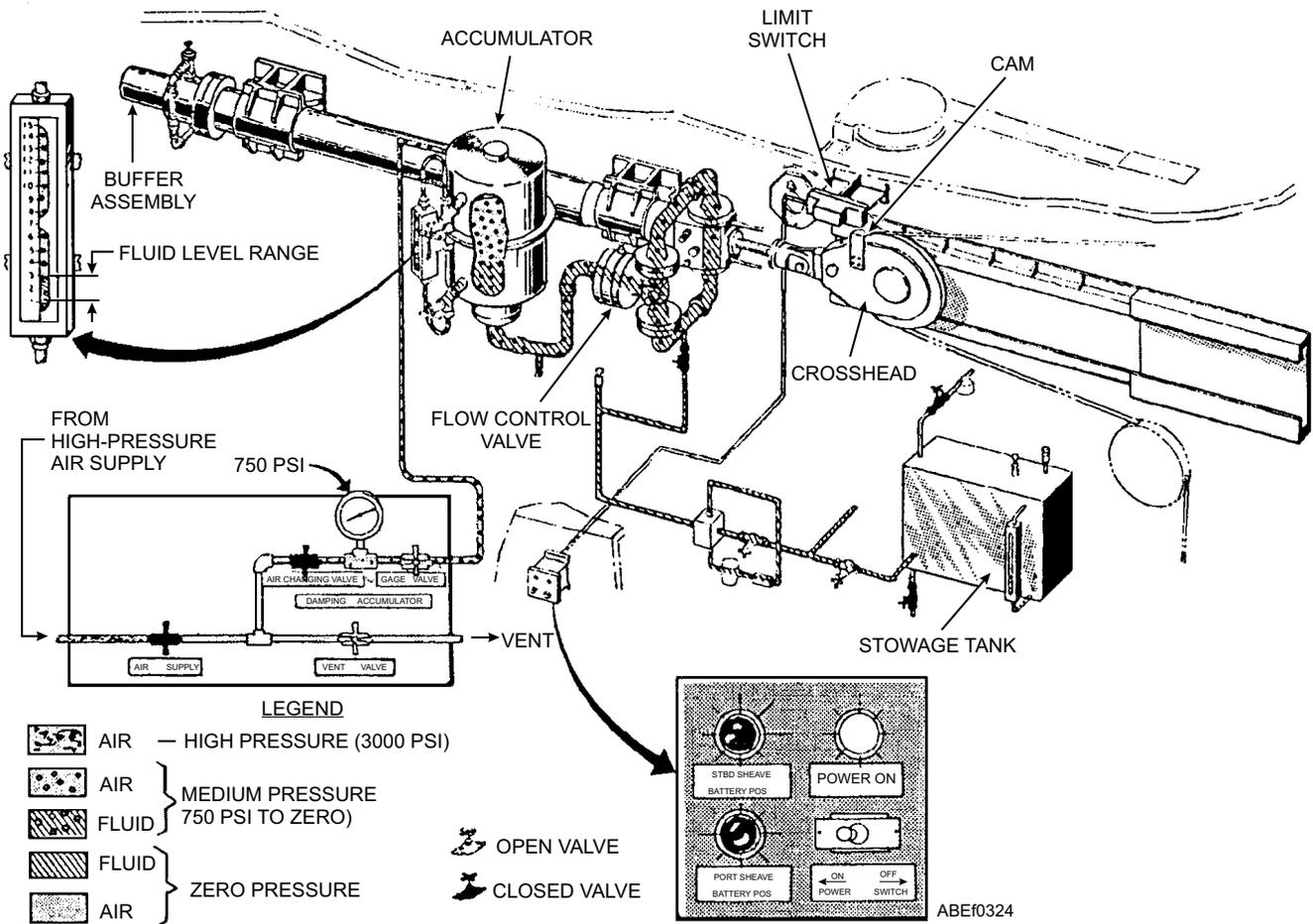
Because of the high engaging velocities of modern carrier-based aircraft, cable tension and vibration would be excessive unless eased by the shock absorption provided by the sheave damper. The sheave damper reduces peak cable tension and lessens cable vibration.

In figure 3-24, a sheave damper assembly is mounted to the ship's structure below each port and starboard retractable or fixed horizontal deck sheave. The port and starboard assemblies are identical; therefore, only one will be discussed.



ABEf0323

Figure 3-23.—Arresting engine drive system.



ABEf0324

Figure 3-24.—Sheave damper installation.

## Description

Each sheave damper assembly consists of a movable crosshead assembly, damper cylinder assembly, damper piston, damper accumulator and fluid piping, buffer assembly, and charging panel. The system is also equipped with a common fluid stowage tank, which provides a stowage space for fluid in the sheave damper assembly while maintenance is being performed. The tank is capable of stowing all the fluid in one sheave damper installation.

The crosshead assembly consists of one roller bearing sheave mounted between a steel base plate and a side plate that are bolted together. A sheave shaft, mounted through the bottom of the base plate, is secured to the side plate by a cap and setscrew. A yoke is bolted between the side plate and the base plate and provides a means of connecting the crosshead to a clevis that is screwed onto the end of a piston rod. The crosshead rides in a track mounted in a horizontal position on the bulkhead.

Phenolic slippers, at all four corners of the base plate, provide a bearing surface between the crosshead and the track. Attached to the crosshead is a cam that actuates a limit switch when the crosshead is fully retracted and causes a green light to light at the deckedge control station. This indicates to the deckedge operator that the sheave damper is in its BATTERY position.

The damper cylinder assembly is secured to the ship's structure by brackets, which are welded to the bulkhead and bolted to the cylinder. A cylinder cap is screwed onto the crosshead end of the cylinder and held in place by setscrews. The cap provides a fluid passage between the cylinder and the fluid manifold piping leading to the damper accumulator. The damper piston rod extends through the cap at the crosshead end of the cylinder. The damper piston is secured onto the opposite end of the piston rod and held in place by a castle nut and cotter pin.

The fluid manifold is bolted to the top and bottom of the cylinder cap. A reducing tee connects the upper and lower manifold piping and serves to divert fluid flow from the accumulator equally into the upper and lower manifolds. A flow control valve is located between the reducing tee and the accumulator. The flow control valve has a flapper-type (swing gate) orifice plate, which allows free flow of fluid from the cylinder to the accumulator and a restricted flow through an orifice in the center of the plate from the accumulator to the cylinder.

The accumulator acts as a fluid stowage tank and has a high-pressure air connection from the upper head to the charging panel. The charging panel has a charging valve and a gauge valve with a gauge mounted between them, a high-pressure air supply valve, and a vent valve. The accumulator is charged to 750 psi and must have a reading of 2 ( $\pm 1$ ) inches of fluid on the fluid sight indicator when the sheave damper is in its BATTERY position.

The end of the cylinder opposite the crosshead end has a flange threaded on it that mate with a flange on the buffer assembly. The two flanges are bolted together. The buffer assembly consists of a cylinder, buffer ram, spring, and fluid sight indicator. The purpose of the buffer assembly is to buffer the damper piston when returning to its BATTERY position.

## Operation

An incoming aircraft engages the deck pendant, causing an increase of tension on the purchase cable. The purchase cable is reeved around the sheave damper crosshead in a manner that any increased tension experienced by the purchase cable will cause the sheave damper crosshead to move away from its BATTERY position. As the sheave damper crosshead moves, the damper piston moves, forcing fluid from the cylinder, through the fluid manifold, flow control valve, and fluid piping, into the accumulator. The resulting pressure buildup in the accumulator will be equal to the purchase cable pull.

Retraction of the sheave damper is automatic and occurs when accumulator pressure becomes greater than cable tension. Retraction normally occurs prior to full runout of the aircraft. The pressure buildup in the accumulator forces the fluid from the accumulator, through the fluid piping, the orifice in the flapper of the flow control valve, the reducing tee, and the fluid manifold, to the damper cylinder, therefore forcing the damper piston back to its BATTERY position. Just before the damper piston reaches its BATTERY position, the end of the damper piston rod comes in contact with the buffer ram.

The force of the damper piston rod pushing on the buffer ram compresses a spring inside the buffer cylinder. The spring is held in place by the buffer cylinder end plug. The compression of the spring buffers the return of the damper piston to its BATTERY position.

As the sheave damper crosshead reaches its BATTERY position, the battery-position indicator limit

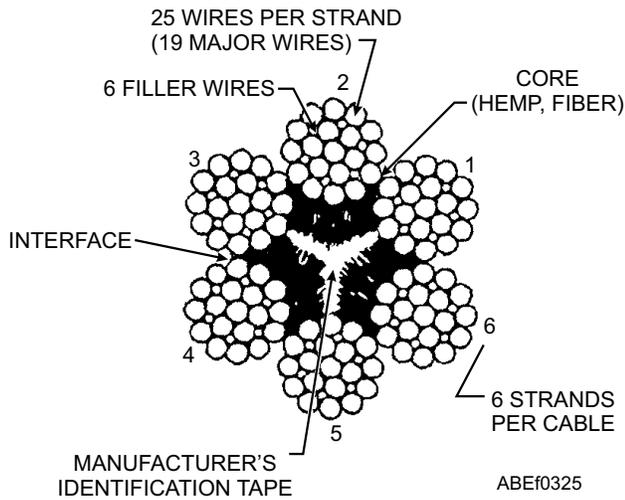


Figure 3-25.—Cross section of preformed sisal core purchase cable.

switch is engaged, and lights the battery-position indicator light at deck edge.

### Purchase cable

The purchase cable is the wire rope reeved onto the arresting engine sheaves and fed through fairlead tubing and over the fairlead sheave to the deck gear on the flight deck. The purchase cable transmits the force of the landing aircraft from the deck gear to the arresting engine.

The polyester-core purchase cable is 1 7/16-inch diameter, 6 × 31 die-formed polyester-core construction with no filler wires, all wires are considered loading bearing, with a minimum breaking strength of 215,000 pounds. The die-formed construction is such that the outer wires present a relatively flat surface, giving it the appearance of being worn even when new.

As a result Q reading, as performed on the sisal-core purchase cable, are not possible. Inspection and replacement will be based on broken wire criteria.

The sisal-core purchase cable is 1 7/16-inch diameter, 6 × 25 filler wire construction, right-hand lay, lang lay cables with a minimum breaking strength of 195,000 pounds. The 6 × 25 filler wire construction means that the cable is made up of 6 strands with 19 major wires and 6 filler wires per strand. (See fig. 3-25.) The filler wires provide shape and stability to the strand. Lang lay denotes cables in which the wires of the strand and the strand are twisted in the same direction so that the outer wires in the lang lay cables run diagonally across the longitudinal axis of the cables.

The purchase cable is made from high-strength, uncoated plow steel. A hemp center, made from resilient oil-impregnated hemp, serves as a foundation for the strands, keeps the strands evenly spaced, and prevents them from bearing against each other. The hemp center also aids in lubrication of the inner wires. Within the hemp center is buried a paper or plastic strip bearing the name of the manufacturer. New purchase cables are provided on a double reel with each reel containing 1100 feet of cable. The purchase cable used on a barricade engine is of the same wire rope construction but is provided as a single cable, 2100 feet in length with a poured terminal on one end.

Poured threaded terminals are fitted on each end of the purchase cables. A clevis socket is screwed onto the threaded terminals to connect the purchase cables to the crossdeck pendants one end, the other end is connected to a coupling on the cable anchor damper operating piston rod (fig. 3-26.)

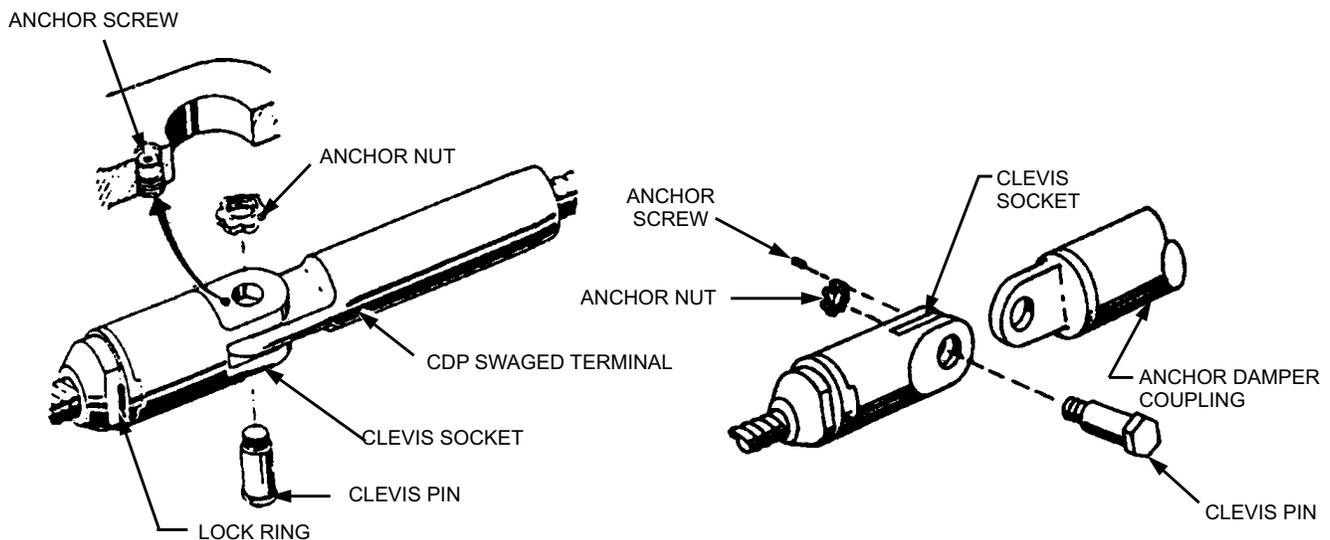


Figure 3-26.—Purchase cable attachments.

The Mk 7 arresting engines have an 18:1 reeve ratio, which means for every foot of ram travel there are 18 feet of purchase cable payout. The number of sheaves on the crosshead determines the reeve ratio. The types of reeves used on the Mk 7 arresting engines are 18:1 single reeve on pendant engines, and 18:1 endless reeve on barricade engines. The endless reeve barricade engines use only one purchase cable with the two bitter ends terminating on the flight deck and connected to the barricade. The single-reeved pendant engines require two purchase cables, one reeved around the 28-inch pitch diameter sheaves and one reeved around the 33-inch pitch diameter sheaves of the fixed sheave and crosshead assemblies.

### FAIRLEAD SYSTEM SHEAVES

Three types of sheaves are used in Mk 7 arresting gear. They are the horizontally mounted retractable sheave, the vertical through-deck sheave, and the fairlead sheave. All these sheaves are designed to accommodate 1 7/16-inch diameter purchase cable and are made of forged aluminum alloy.

A typical sheave includes a base and cover that retains the sheave assembly. See figure 3-27. Two grease fittings provide access for lubricating the sheave bearing and spacers. The sheave assembly has three races: an inner race, a bearing race, and an outer race. Mounted with each sheave is a two-piece concentric spacer. The inner spacer is made of steel and is the lubricant distributor. The outer spacer, made of phenolic, is bonded to the sheave, provides a bearing surface, and is a lubricant retainer for the sheave. The horizontal and vertical sheaves are identical except for their mounting arrangement.

The function of a retractable sheave is to provide a means of lowering deck sheaves that would interfere with the passage of aircraft and deck equipment when in the raised operating position. Figure 3-28 is an example of a retractable sheave installation.

Each retractable sheave is operated by an electric motor unit controlled by a deckedge push-button station. In addition, an indicator light box is installed adjacent to the deckedge push-button station to show the position of the sheave—a green light when the sheave is fully raised, or a red light in all positions other than fully raised. The retractable sheaves may also be operated by means of handwheels in case of emergency. The handwheel is located below decks on the operating unit. To eliminate the chance of the retractable sheave being lowered inadvertently during

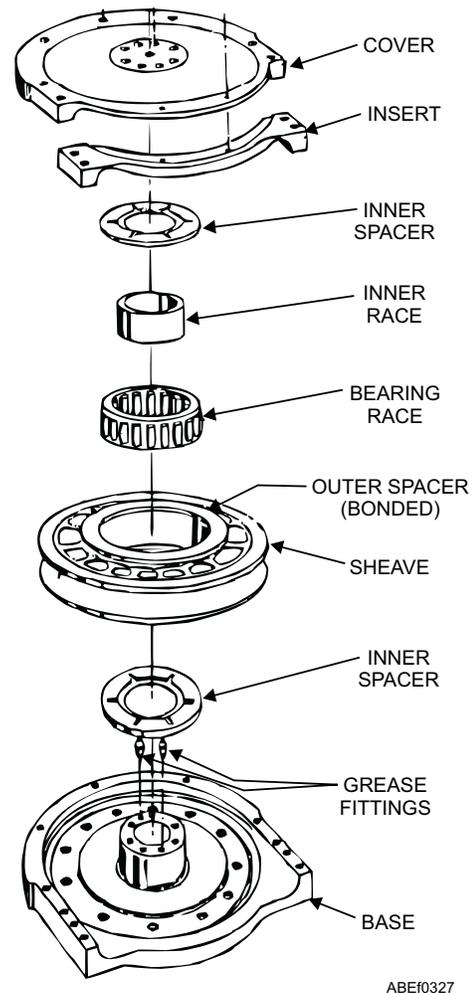


Figure 3-27.—Typical sheave assembly.

landing operations, the handwheel is removed from the unit whenever it is not actually being used.

The retractable sheave operating unit is bolted to the bottom of the retractable sheave assembly. It is accessible for maintenance and manual operation from the compartment that is directly below the retractable sheave.

The retractable sheave operating unit is a self-contained unit consisting of a high-torque electric motor, a geared drive system, and limit switches. See figure 3-29.

The motor is coupled to the wormshaft, which has a worm splined to the shaft. The worm engages the worm gear, which is free to rotate on the sleeve. There are two lugs on the back of the worm gear that, after some free rotation, engage two lugs on the back of the clutch bevel gear. The free rotation is to prevent putting an immediate load on the electric motor. The clutch bevel gear is splined to the sleeve, so that any rotation of the clutch bevel gear rotates the sleeve.

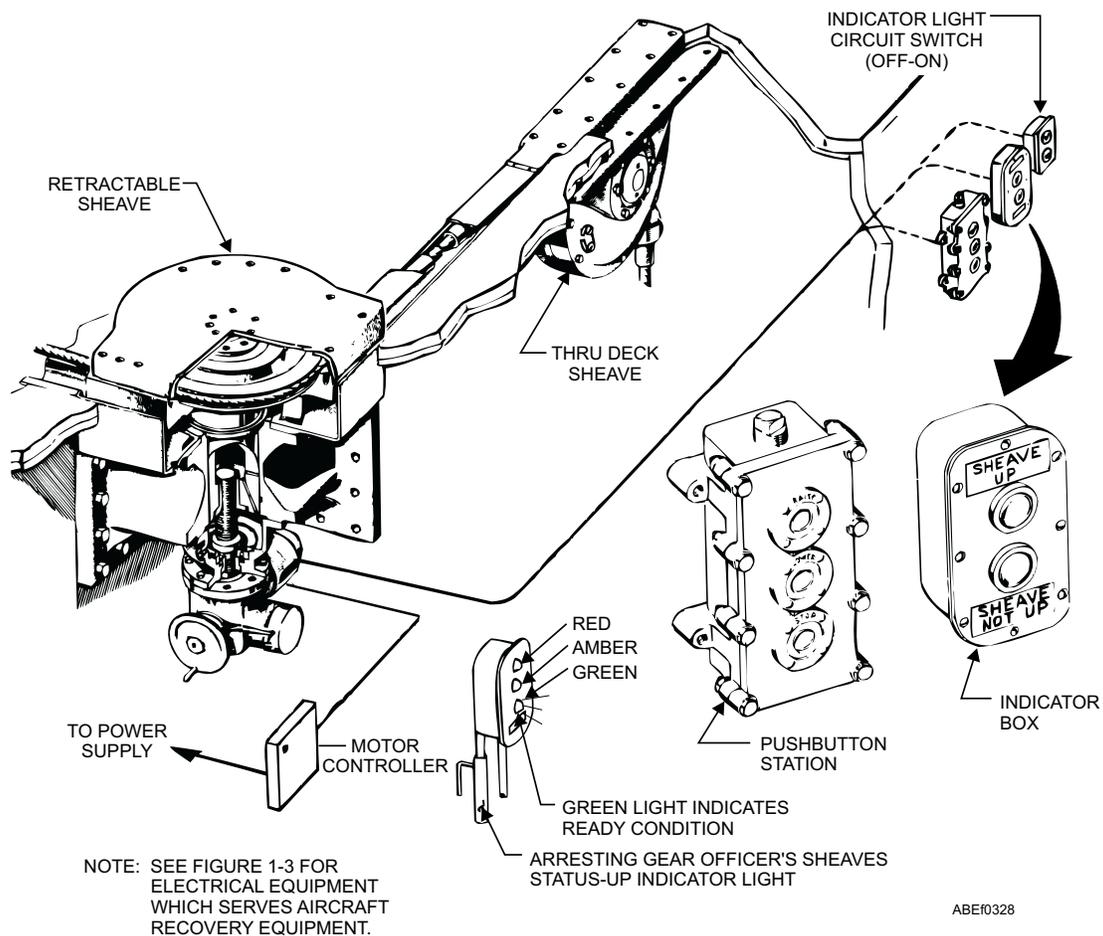
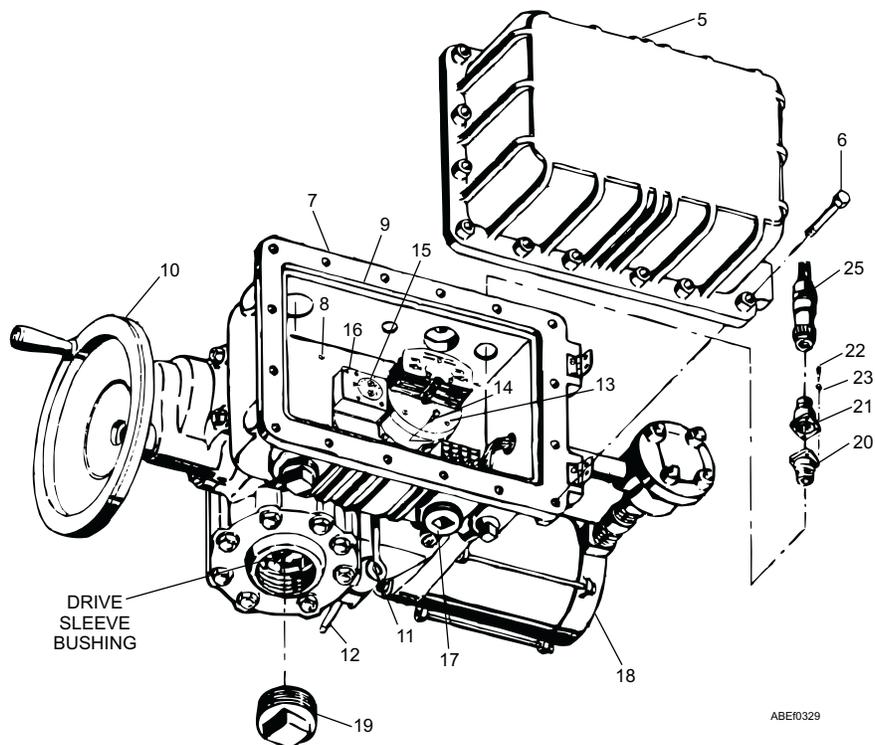


Figure 3-28.—Retractable sheave installation.



- |                        |                       |                          |                         |
|------------------------|-----------------------|--------------------------|-------------------------|
| 1. Geared limit switch | 5. Lower bevel gear   | 9. Tripping plate washer | 13. Torque spring       |
| 2. Motor               | 6. Pinion             | 10. Worm gear            | 14. Declutch lever      |
| 3. Housing             | 7. Clutch fork spring | 11. Handwheel            | 15. Worm                |
| 4. Sleeve              | 8. Clutch bevel gear  | 12. Wormshaft            | 16. Torque limit switch |

Figure 3-29.—Retractable sheave operating unit.

The sleeve is directly keyed to the lead screw of the retractable sheave so that rotation of the sleeve raises or lowers the sheave. The amount of sleeve rotation while the sheave is rising is governed by the adjustable geared limit switch, which opens the motor circuit when the sheave is fully up. An adjustable torque limit switch, actuated by the tripping plate washer, opens the motor circuit when the sheave is fully lowered and further provides overload protection for the unit. The worm is normally held in position with a heavy torque spring. If an obstruction under the sheave prevents the sheave from lowering, the sleeve cannot turn. Then the torque exerted by the worm exceeds the normal torque, causing the worm to slide along the wormshaft, pushing the tripping plate washer, and opening the torque switch. A handwheel is provided for manual operation, and a declutch lever is provided to change from motor to hand operation.

It is imperative that the deckedge operator knows whether the retractable sheave is in the UP position during landing operations. During night operations, visual sighting of the retractable sheave is impossible.

An arresting gear SHEAVE-UP and BY-PASS switch and indicator panel (fig. 3-30) is located aft of the arresting gear deckedge control station to indicate the status of the retractable sheave. The panel is wired into the clear/foul deck light and will prevent the

arresting gear officer from giving a clear deck signal if one or more of the retractable sheaves is not in the fully up position.

If a retractable sheave cannot be raised, the arresting gear officer directs that the affected deck pendant be removed from the deck. A CLEAR DECK signal can now be activated by closing the respective by-pass switch and thus overriding the shutdown arresting engine. An amber warning light on the by-pass switch and indicator panel visually indicates the by-pass condition. In addition, a three-lamp, deckedge indicator panel with red, amber, and green lenses, mounted aft of the deckedge control station, will indicate the retractable-sheave status. This panel will illuminate red when any of the retractable sheaves are down and green when all sheaves are up. In case one or more arresting engine and retractable sheave is bypassed, the deckedge indicator light will display the green and amber lights.

### SEQUENCE OF OPERATION

Energizing the motor to raise the retractable sheave, by pressing the RAISE push button, causes the motor to rotate a helical gear keyed to its shaft. This transmits the motor force to another helical gear on the wormshaft. The wormshaft turns the worm and drives

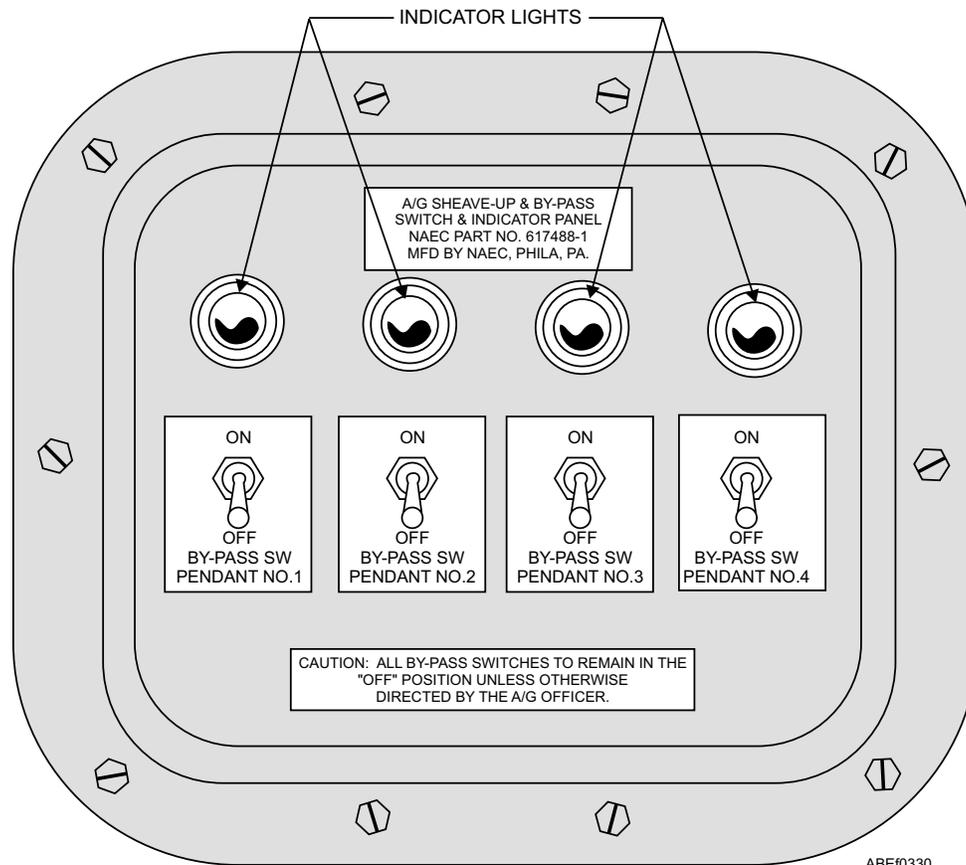


Figure 3-30.—Sheave-up and by-pass switch and indicator panel.

the worm gear on the sleeve. The worm gear rotates freely on the sleeve for part of the rotation, thus permitting the motor to gain speed before full loading. As the worm gear rotates, the lugs on its face engage the lugs on the face of the clutch bevel gear. Rotation of the clutch bevel gear, which is splined to the sleeve, rotates the sleeve, which is directly connected to the screw of the retractable sheave, thus raising the sheave. When the sleeve rotates, the limit bevel gear, keyed to the sleeve, rotates to turn the pinion of the geared limit switch. This is the only function of the limit bevel gear. When a predetermined point is reached by the rotor of the geared limit switch, the RAISE circuit is broken and the raising operation ceases. As the geared limit switch is actuated, the green lamp (sheave UP lamp) will light in the deckedge light box.

Energizing the motor to lower the retractable sheave, by depressing the LOWER push button, causes the motor and the drive system to operate in the reverse direction. Again there is free rotation until the lugs on the worm gear make a complete revolution before striking the other side of the lugs on the clutch bevel gear. The sheave lowers until it is completely seated and opens the torque limit switch to break the motor circuit. If an obstruction prevents the sheave from descending, the worm, which is still rotating because of the force of the motor, does not turn the worm gear. The worm is driven axially along the wormshaft until the torque limit switch is opened by the tripping plate washer. The torque limit switch may be adjusted to permit the sheave to seal with a predetermined force before the circuit is interrupted. The torque spring then absorbs the remaining inertia of the system after the circuit is broken. During the time the sheave is lowered and raised up until the time the RAISE geared limit switch is tripped, the red (sheave NOT UP) lamp glows on the deckedge light box.

For manual operation, the handwheel must be mounted on its shaft and secured to the shaft with a setscrew. The declutch lever must then be thrown in a counterclockwise direction. This movement will slide the clutch bevel gear along the splined section of the sleeve to engage a gear on the handcrank shaft. When the handcrank is turned, the sleeve turns, rotating the sheave screw to raise or lower the sheave. The declutch lever remains in the clutch position until operation under motor power is resumed, at which time the handwheel is disconnected automatically by the clutch trippers. There is no danger to an operator if he or she is turning the handwheel when the motor is started, because the handwheel is disengaged instantly without shock or jolt.

## Thru-deck Sheave

The thru-deck sheave (fig 3-23) is mounted vertically and it guides the purchase cable between the sheave damper and the retractable sheave installation.

## Fairlead Sheaves

Fairlead sheaves (fig. 3-23) are single sheaves that are installed at points in the drive system where the purchase cable require a change of direction. The number of fairlead sheaves varies based on engine location in relation to the location of the anchor and sheave dampers.

## Crossdeck Pendants

The polyester-core crossdeck pendant are made of 1 7/16-inch diameter, 6 × 30 flattened strand polyester core construction with no filler wires, all wires are considered loading bearing with a minimum breaking strength of 205,000 pounds. To differentiate polyester-core CDPs from sisal-core CDPs the polyester-core terminals have a groove around the end where the cable enters the terminal. The deck pendant cable ends are equipped with swaged-type terminals. These terminals are pinned to the clevis and socket assembly at the purchase cable coupling for quick detachment during replacement.

The sisal-core crossdeck pendant are made of 1 3/8-inch diameter, 6 × 30 flattened strand construction, preformed, uncoated lang lay wire rope with a minimum breaking strength of 188,000 pounds. Each wire rope is made up of 6 steel strands, each of which is a bundle of 12 major and 12 intermediate wires twisted around a triangular core of 3 to 9 wires. (See fig. 3-31.) The strands are twisted about an oiled-hemp center

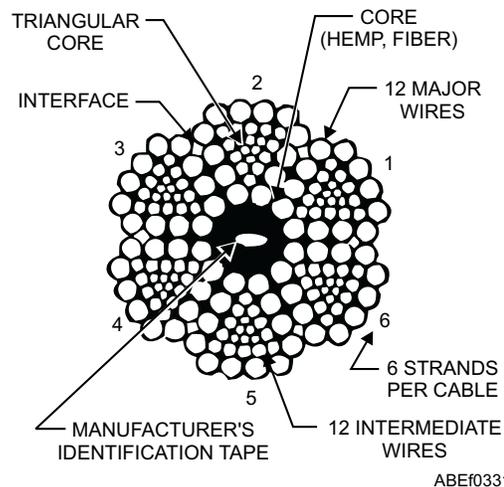
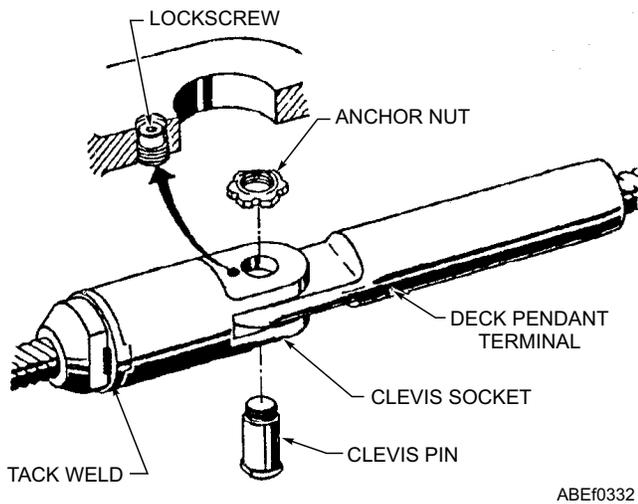


Figure 3-31.—Cross section of preformed sisal core 6 × 30 crossdeck pendant.



**Figure 3-32.—Deck pendant terminal and clevis socket assembly.**

core, within which is contained a paper or plastic tape strip bearing the name of the wire rope manufacturer. The function of the oiled hemp center is to provide a "cushion" for each strand and also to supply lubrication when the cable is under tension. The deck pendant cable ends are equipped with swaged-type terminals. These terminals are pinned to the clevis and socket assembly at the purchase cable coupling for quick detachment during replacement.

To remove a pendant, it is necessary to put slack in the cable. If the pendant has been retrieved and must be replaced, reduce the accumulator pressure to 200 psi and pull the pendant out a few feet, using a deck tractor. Hold the retracting valve open while the tractor is

pulling, then block the valve in the closed position to prevent retraction. It may be necessary to clamp a block on the purchase cable to prevent its slipping back due to its own weight. If a pendant is badly damaged during an arrestment and must be replaced immediately, either do NOT retract the pendant or retract the pendant only partially so that slack is left in the cable system.

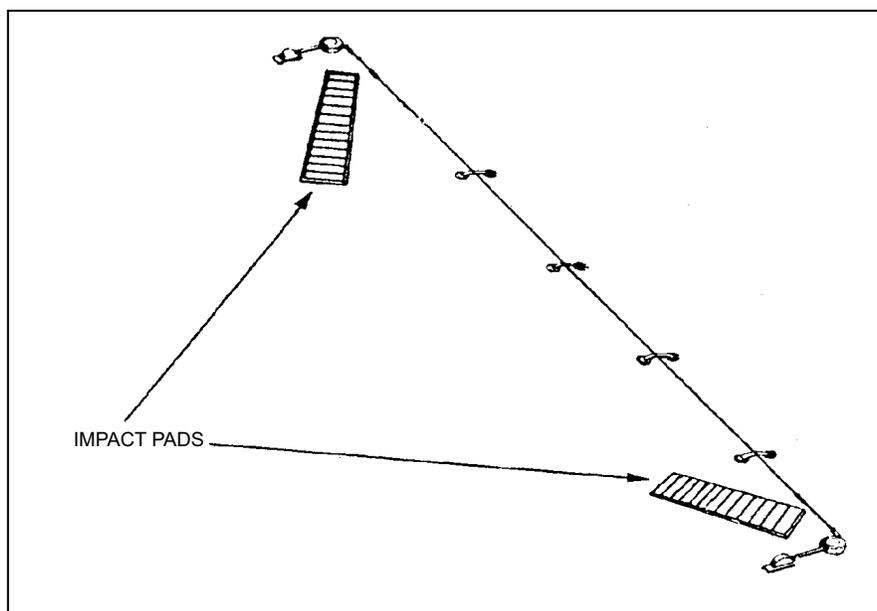
Refer to figure 3-32, and perform the following task to replace a deck pendant. Screw the lockscrew into the clevis end socket, remove the anchor nut and pull out the clevis pin. Secure the eye end of the terminal of the new deck pendant to the clevis end socket of the purchase cable socket assembly by means of the clevis pin, anchor nut, and the lockscrew. Recharge the accumulator and retract the engine.

Deck pendants are provided as assemblies—not made up on board ship. Suitable handling facilities should be available. Spare pendants should be conveniently stowed, ready for quick rigging, since replacement of a deck pendant is sometimes an emergency procedure that must be performed quickly.

The replacement operation can best be performed by four separate crews. One crew is needed to pull out the pendant, one at each of the two couplings, and one to bring the new pendant on deck and roll it out and in position.

### Impact Pads

Impact pads (fig. 3-33) are made up of several sections of polyurethane pads laid side by side and secured within an outer steel frame. The frame is both



**Figure 3-33.—Terminal impact pads.**

welded and bolted to the flight deck inboard of each of the deck sheaves at an approximate 45 degrees forward facing angle. The bolted section of the frame is removable in order to replace worn impact pads as needed. Upon initial arrestment by an aircraft the terminal will impact on the pads instead of the steel deck, minimizing damage to the fittings, purchase cable, and crossdeck pendants.

### Wire Supports

The wire supports provide a method of raising the crossdeck pendant off the flight deck to ensure arresting (tail) hook engagement of the incoming aircraft.

These wire supports are actually preshaped leaf springs that are designed to maintain a crossdeck pendant height of 2 inches minimum, measured from the bottom of the pendant to deck at its lowest point, and 5 1/2 inches maximum, measured from the top of the pendant to the deck at its highest point (fig. 3-34). The crossdeck pendant height is regulated by adjusting the wire support's contour height.

Each wire support is mounted directly to the flight deck. The forward end of the wire support spring is rigidly secured by use of a cam mounted in a deck recess and a follower and pin at the end of the wire support. The forward end of the spring is then held in

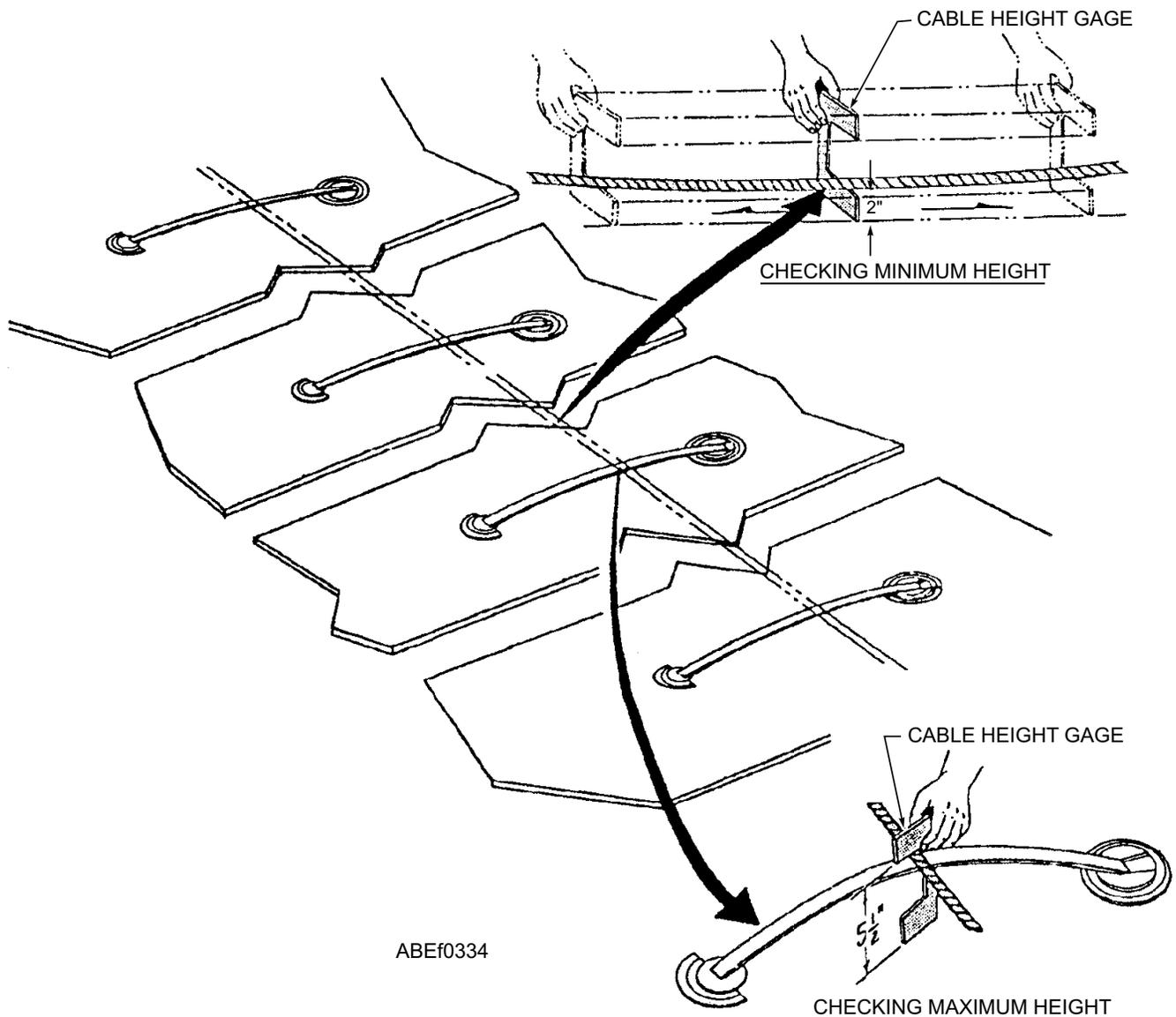


Figure 3-34.—Checking crossdeck pendant height.

the deck recess by the cam-end disc and the cam-end forward stop (fig. 3-35).

Adjustment of the wire support spring height is made at its aft end. The aft end of the wire support is also pinned, and set between adjustable forward stops as required (fig. 3-35).

Wire supports are replaced when they become deformed or damaged or when they fail to maintain the required crossdeck pendant height of 2 inches minimum and 5 1/2 inches maximum as measured using a cable height gauge (fig. 3-34).

### REVIEW QUESTIONS

- Q1. What is considered the heart of the arresting engine?
- Q2. What permits the return of hydraulic fluid from the accumulator to the main engine cylinder?
- Q3. What is the capacity of the fluid stowage tank?
- Q4. What is the pitch diameter of the sheaves on the outboard shaft of the crosshead assembly?

Q5. What system transfers energy from an arresting aircraft to the arresting engine?

Q6. What reduces peak cable tension?

### EMERGENCY RECOVERY EQUIPMENT

**LEARNING OBJECTIVES:** Describe the components of the emergency recovery equipment. Describe the operation of the emergency recovery equipment.

The emergency recovery equipment (barricade installation) is used when an aircraft cannot make a normal (pendant) arrestment. Emergency recovery equipment consists of the following:

- Barricade power package
- Pendant and anchor installation
- Barricade stanchions and controls
- Barricade webbing assembly
- Deck ramp installation

The arresting engines used for barricade arrestments are identical to those used for deck pendant

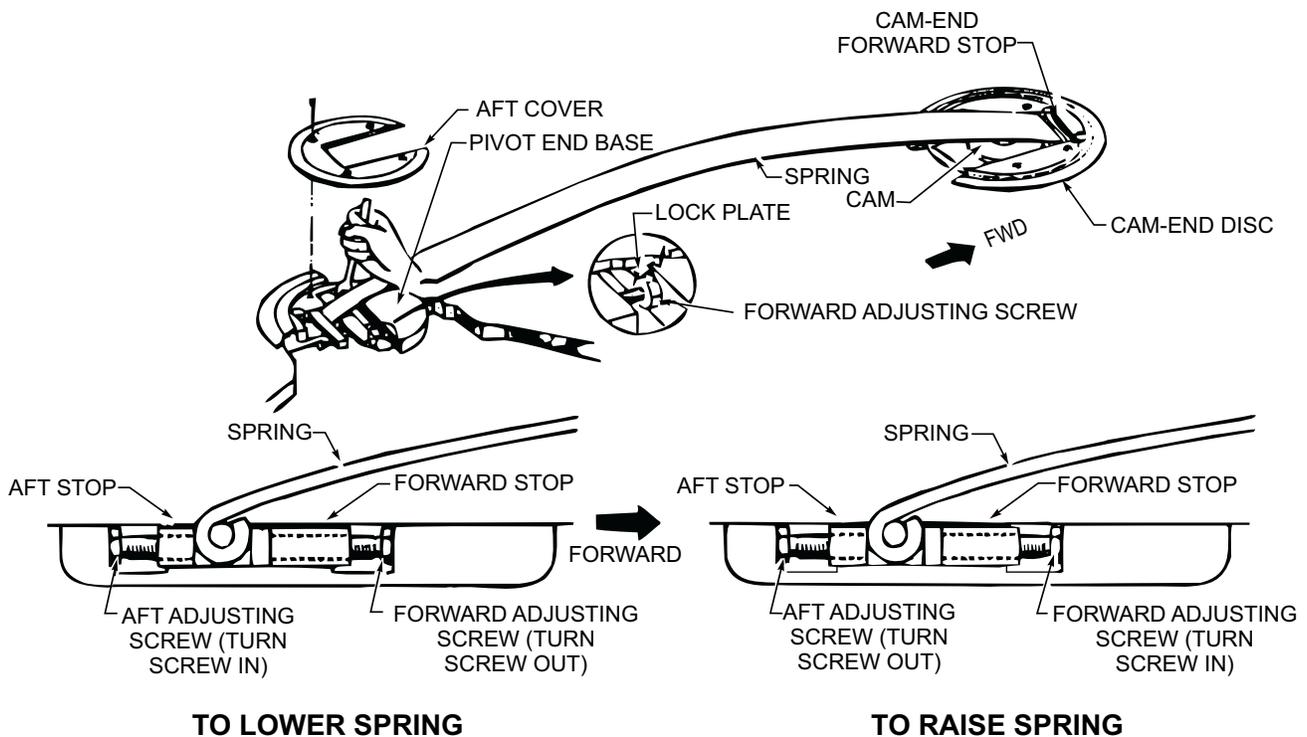


Figure 3-35.—Adjusting the wire support leaf spring height.

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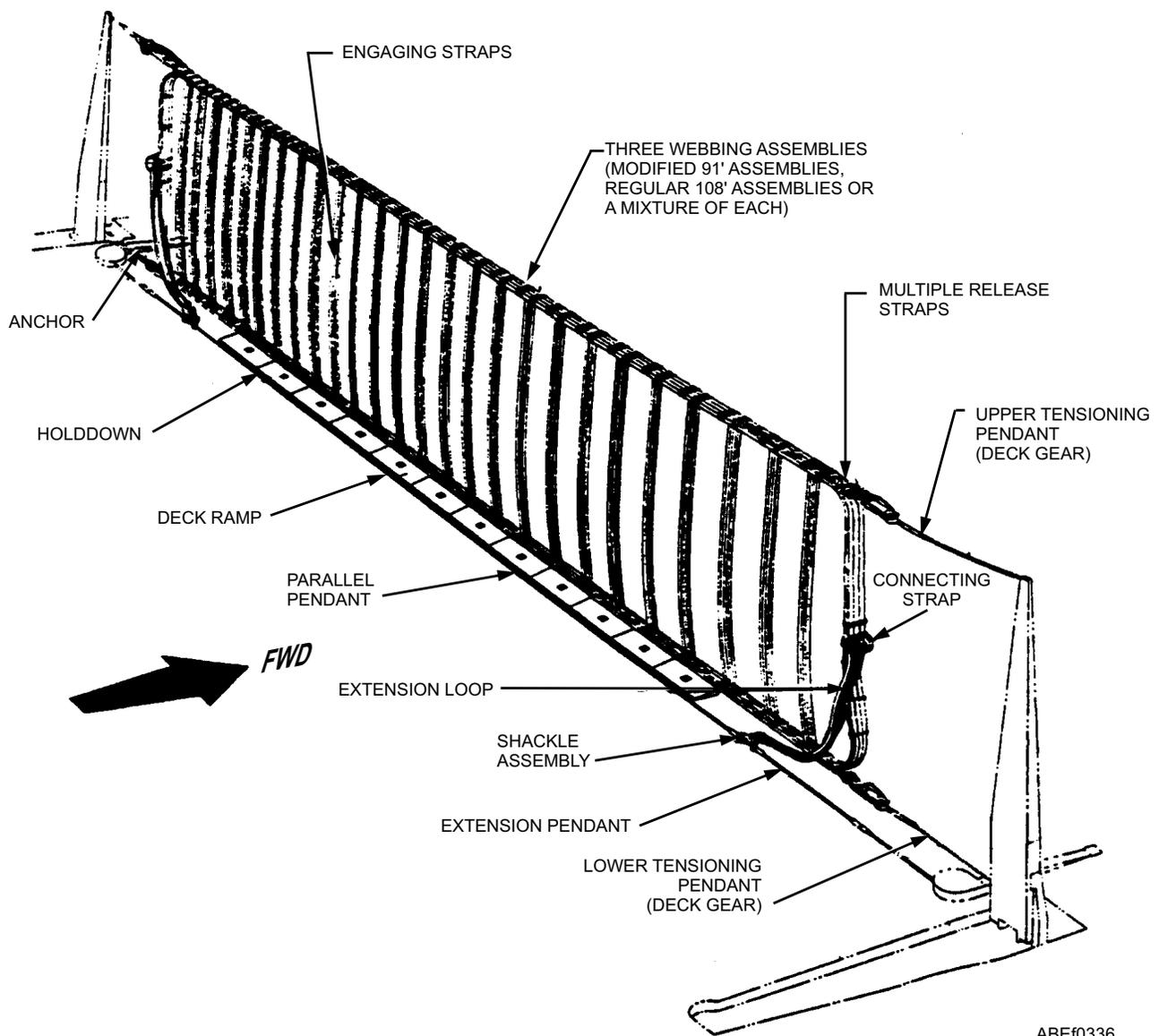
arrestment with four exceptions: (1) no fluid coolers are installed, (2) barricade engines are endless reeved, (3) no anchor dampers are installed, and (4) a short-stroke control valve cam is used on most carriers.

### BARRICADE WEBBING ASSEMBLY

Since barricade arrestments are emergency situations, barricade-rigging operations must be swift and efficient. The barricade webbing assemblies (fig. 3-36) are assembled and stored in an area where the webbing assemblies will be readily accessible when an emergency situation arises. The barricade storage room is equipped with a rack designed to stow three barricades simultaneously:

- READY— Jet Barricade
- STANDBY— Jet Barricade
- PRACTICE— Jet Barricade

The E2/C2 barricade is also stowed in the stowage room. The storage area for the webbing assemblies must be dry and must protect the webbing from exposure to direct sunlight. The effects of water on a barricade webbing assembly will result in the loss of approximately 10 to 15 percent of the webbing's strength and its weight increases by approximately 40 to 45 percent. However the strength loss and increase in weight are not permanent. When the webbing is dry to the touch the original barricade strength and weight are regained .



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Figure 3-36.—Barricade webbing installation.

Newly constructed barricade webbing assemblies may be brought out of storage and used as follows:

- If used for three practice rigs, it can still be used as a "ready" barricade for engagements.
- If used for four or more practice rigs, it cannot be used as a "ready" barricade.

When an aircraft is required to make an emergency landing, the nose of the aircraft passes through the barricade and allows the vertical (engaging) straps to contact the leading edges of the wings and wrap about the aircraft (fig. 3-37). The barricade installation then passes the force of arrestment through the purchase cable to the arresting engine. After arrestment, the barricade and attached hardware are discarded.

Currently, there are two types of barricades (two configurations) available to the fleet. Both types consist of all-nylon webbing assemblies, placed one on top of

the other and bundled together to make up one barricade installation (see fig. 3-36).

The polyurethane semicoated barricade uses three separate webbing systems to make one main webbing assembly

Each semicoated barricade webbing system is composed of upper and lower horizontal load straps (see fig. 3-36) joined together at the ends by nylon velcro tie-down straps. (The rolled edges of the upper and lower load straps are coated with polyurethane to reduce wear and damage caused when the barricade is dragged into position for use.)

Vertical engaging straps, are looped around the upper and lower load strap of each webbing system and sewn.. The spacing between the vertical engaging straps affords equalized loading of the barricade during arrestment. One webbing assembly, effects equalized loading every 4 feet along the wing's leading edge

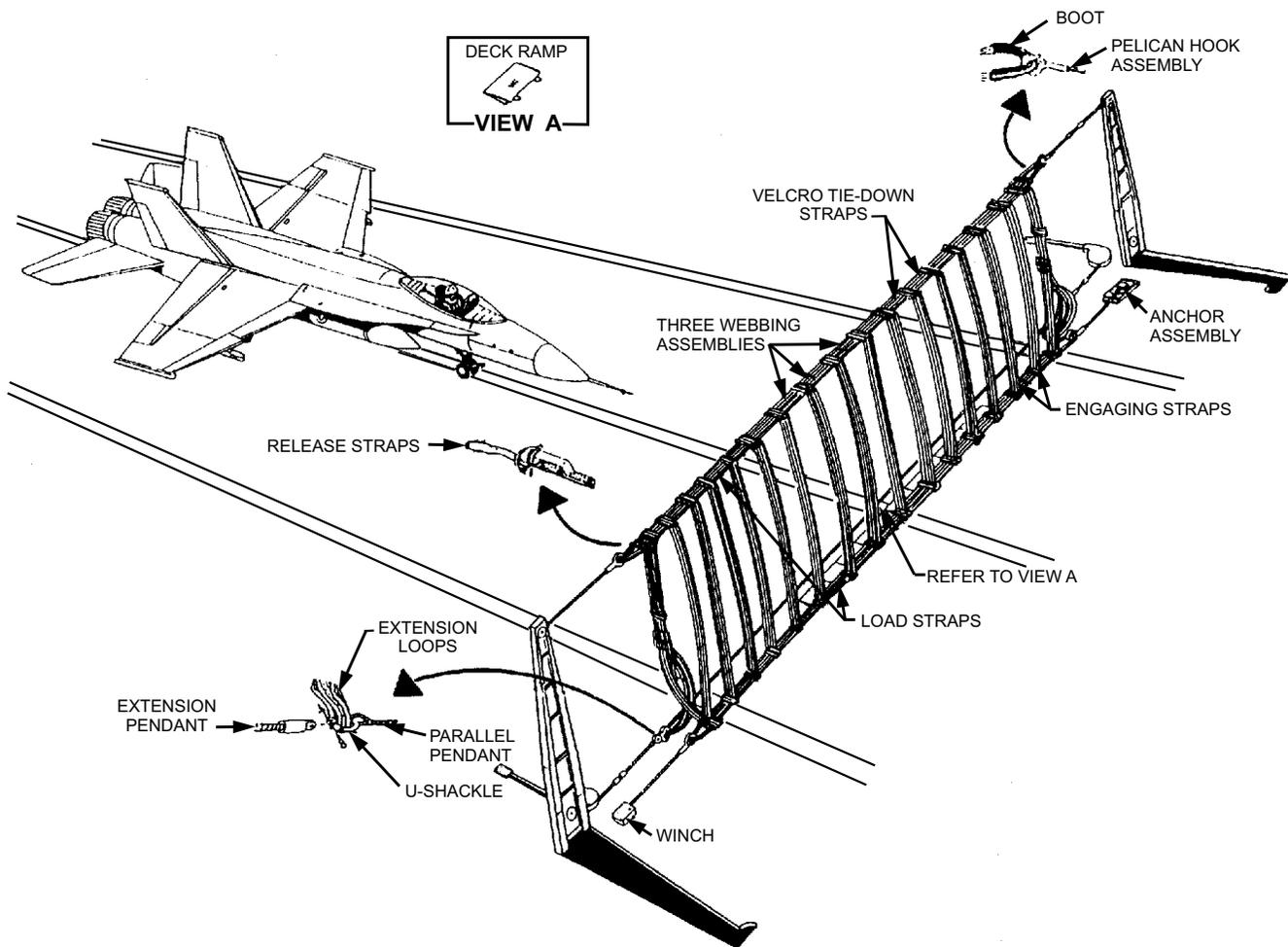


Figure 3-37.—Emergency arrestment.

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because of the staggered arrangement of the vertical engaging straps.

The second barricade configuration (fig. 3-38) is the E-2/C-2 barricade. A 40 foot opening in the center of the webbing is designed so that props of the E-2/C-2 aircraft can pass through it with minimal damage to aircraft during arrestment. The E-2/C-2 barricade installation is comprised of an uncoated, double webbing assembly which is factory preassembled, boxed and shipped ready to rig.

## DECK RAMPS

There are 12 portable deck ramps. They should be numbered 1 through 12 from port to starboard. The numbering should be large enough to facilitate easy identification and placement in corresponding positions on the flight deck.

The purpose of the deck ramps is to secure the lower load straps in place and cause the aircraft nose wheel to ride up and into the barricade assembly. This protects the lower load straps and also prevents the aircraft from nosing under them during a barricade arrestment.

Deck ramps are normally installed by V-1 division personnel during barricade rig evolutions.

## MULTIPLE-RELEASE ASSEMBLY

The multiple-release assemblies provide the connection between the upper and lower load straps of the barricade and the tensioning pendants of the barricade stanchions. They serve to release the webbing assembly during an aircraft engagement (figs. 3-36 and 3-38.)

The multiple-release assembly consists of a number of release straps attached to loops at the ends of

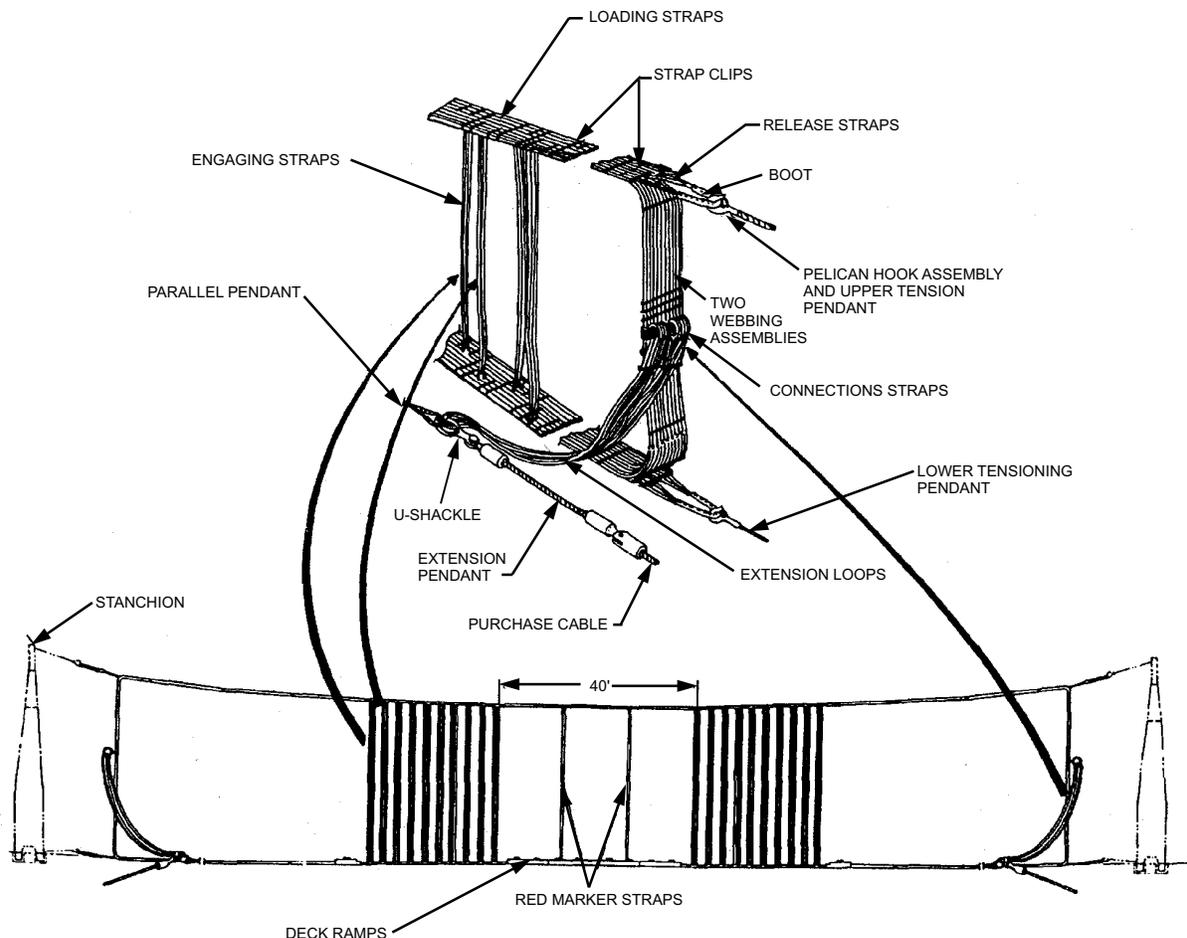


Figure 3-38.—E2/C2 aircraft barricade installation.

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the load straps. They are then attached to the tensioning pendants by a pelican hook assembly. During an emergency arrestment, the force of the aircraft engaging the barricade breaks the multiple-release straps, releasing the barricade from the tensioning pendants allowing it to fall over the aircraft. The energy of the engagement is then transferred from the barricade through the purchase cable to the arresting engine.

### BARRICADE STANCHIONS

Barricade stanchions house the winches that tension and support the barricades. They further provide the structure on which the barricade is raised or lowered.

Except for differences of location and position of the actuating apparatus—deckedge, above or below deck—port and starboard stanchions are identical. The

port stanchions with their actuating apparatus are described in this chapter. Barricade stanchions (fig. 3-39) are welded steel, tray-shaped assemblies that consist essentially of a base on which is hinged the frame. Each barricade frame contains the winches, sheaves, and pendants used to tension the upper barricade webbing load strap.

Each barricade stanchion is provided with a slot, at the top of the inboard side, through which passes the upper tensioning pendant. The frame moves as a hinge around the two stanchion shafts, the barrel of the hinge being the base and the knuckles of the hinge being the hubs of the stanchion frame. The two shafts act as the pins of the hinge. The actuating arm is keyed and pinned on the outer shaft and is pinned to a holder on the stanchion. Rubber bumper pads are bolted in the deck recess to cushion the shock of lowering the stanchions.

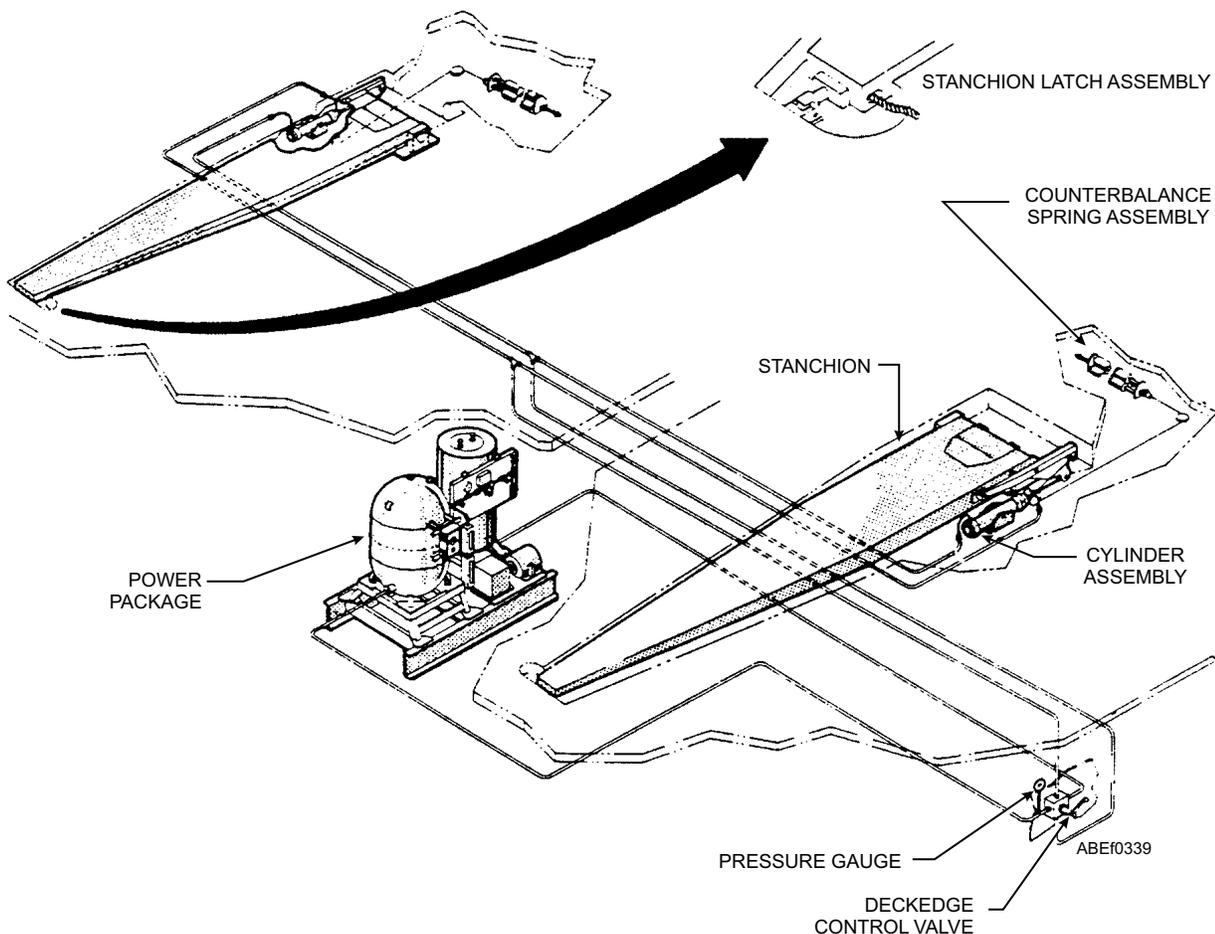


Figure 3-39.—Barricade stanchion installation.

## PENDANT AND ANCHOR INSTALLATION

The pendant and anchor installation (fig. 3-40) is the means by which the barricade webbing is suspended and tensioned to maintain its 20-foot midspan height above the flight deck. Components comprising the pendant and anchor installation are: four wire rope tensioning pendants, two stanchion mounted winches. A deck mounted winch assembly, and an anchor assembly.

### Stanchion mounted winches

One winch is mounted in each barricade stanchion and is attached to the tensioning pendant of the upper loading strap of the barricade.

### Deck winch

The deck winch, through the tensioning pendants provide a means of tensioning the starboard side lower loading strap of the barricade webbing (see fig. 3-40).

### Anchor assembly

The anchor assembly, through the tensioning pendants provides a means of tensioning the port side

lower loading strap of the barricade webbing (see fig. 3-40).

### Tensioning pendants

Tensioning pendants provide the link between the winches, anchor and loading straps to keep the straps in the correct position when a barricade is rigged (see fig. 3-40).

### STANCHION HYDRAULIC CYLINDER

The hydraulic cylinder (fig. 3-41) raises and lowers the barricade stanchion when hydraulic fluid under pressure is introduced into the cylinder on either the raising side of the piston or the lowering side of the piston. A front cap (3) and a rear cap (4) are each attached to the cylinder ends by bolts and sealed by an O-ring (13) and backup rings. Contained in the cylinder (2) are a piston (1), a piston rod (5), and two plungers (6), one on each side of the piston. The piston and plungers are held in position on the rod by a castellated nut and secured by a cotter pin. The piston and piston rod are sealed by an O-ring (13) and backup rings. The piston is fitted with two packing followers, two sets of V-ring packings (12), four rings each, and two piston

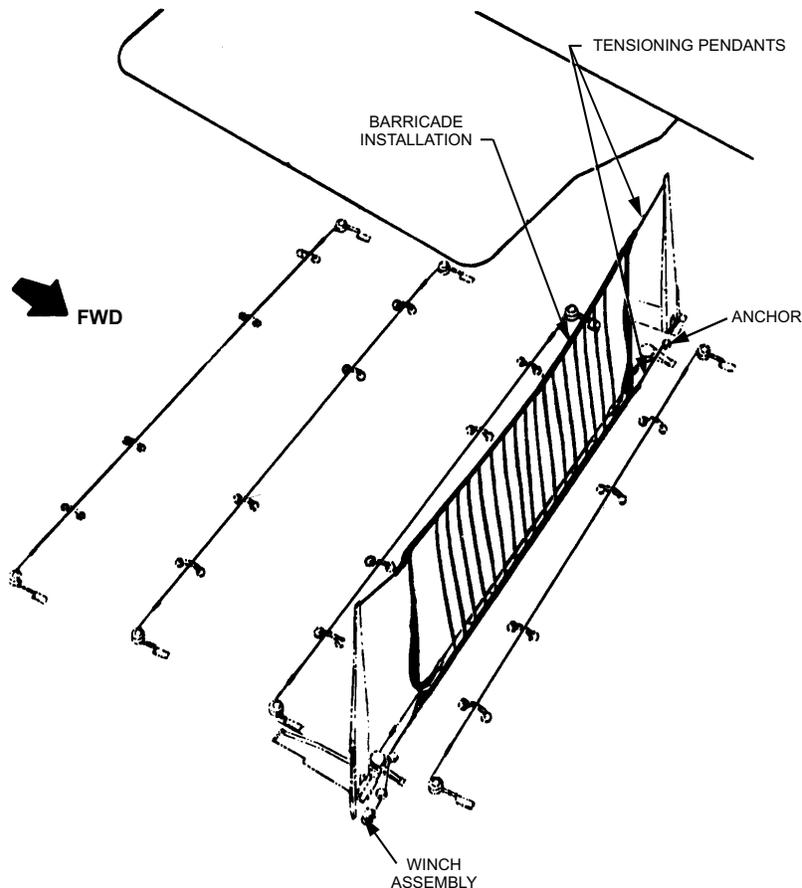
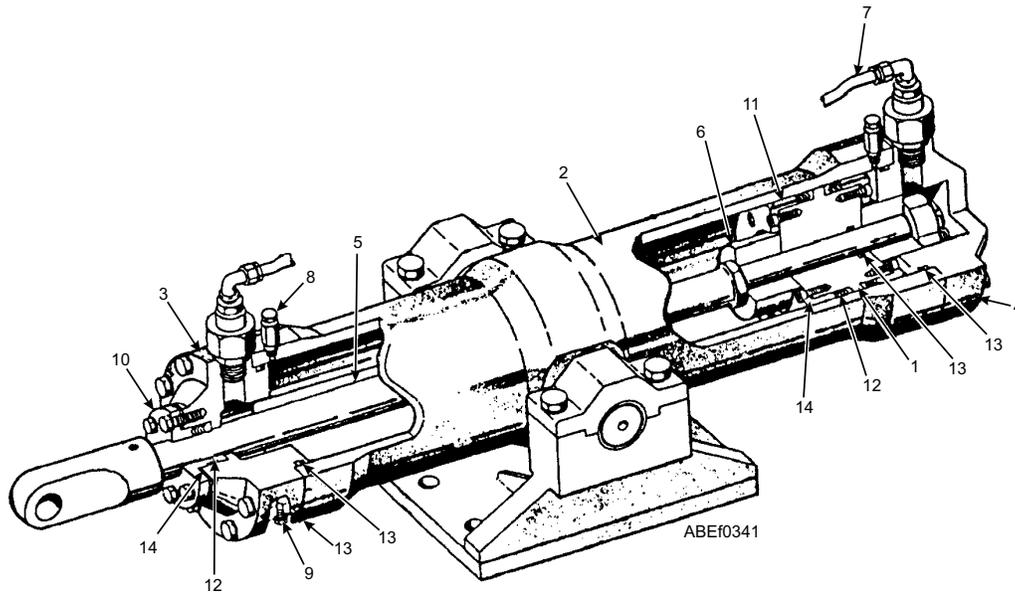


Figure 3-40.—Pendant and anchor installation.

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- |               |                        |
|---------------|------------------------|
| 1. PISTON     | 8. VENT VALVE ASSEMBLY |
| 2. CYLINDER   | 9. PLUG                |
| 3. FRONT CAP  | 10. PISTON ROD GLAND   |
| 4. REAR CAP   | 11. PISTON GLAND       |
| 5. PISTON ROD | 12. PACKING            |
| 6. PLUNGER    | 13. O-RING             |
| 7. HOSE       | 14. SHIM               |

**Figure 3-41.—Hydraulic cylinder assembly.**

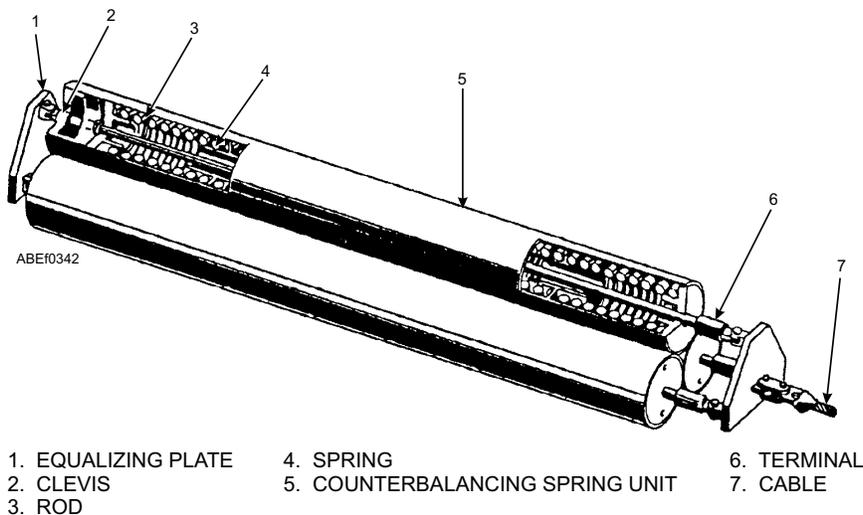
glands (11) secured by bolts, each safety wired. Shims (14) are provided between the piston face and piston gland to obtain the proper packing float. The piston rod is sealed where it extends through the front cap (3) by four V-ring packings (12), a spacer, and piston rod gland (10) secured by bolts and washers. Shims (14) are provided to obtain proper packing float. A terminal is attached to the end of the piston rod and is secured by a setscrew. The front cap and rear face are each fitted with a tailpiece, an adapter, an orifice plate, a union nut, and an elbow to attach hose; joints are sealed by O-rings

and packing. A vent valve assembly (8) and plug (9) are located at each end of the hydraulic cylinder to vent air or drain fluid.

### COUNTERBALANCING SPRING

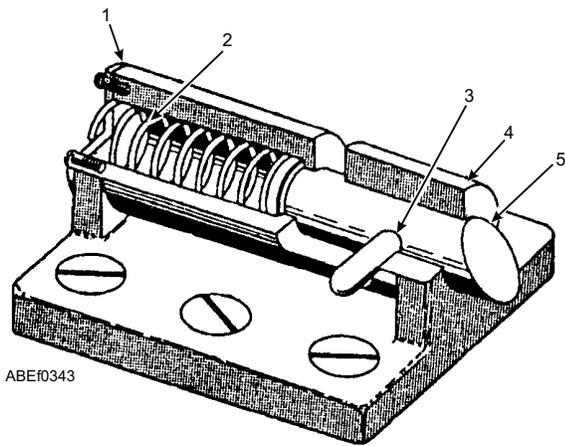
The counterbalancing spring supplements the force of the stanchion cylinder in raising the stanchion, and cushions the contact of the stanchion with the deck.

The counterbalancing spring (fig. 3-42) is a group of three compression spring units (5) comprising five



- |                     |                                 |             |
|---------------------|---------------------------------|-------------|
| 1. EQUALIZING PLATE | 4. SPRING                       | 6. TERMINAL |
| 2. CLEVIS           | 5. COUNTERBALANCING SPRING UNIT | 7. CABLE    |
| 3. ROD              |                                 |             |

**Figure 3-42.—Counterbalancing spring assembly.**



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- |              |          |
|--------------|----------|
| 1. END PLATE | 4. BODY  |
| 2. SPRING    | 5. LATCH |
| 3. PIN       |          |

Figure 3-43.—Stanchion latch assembly.

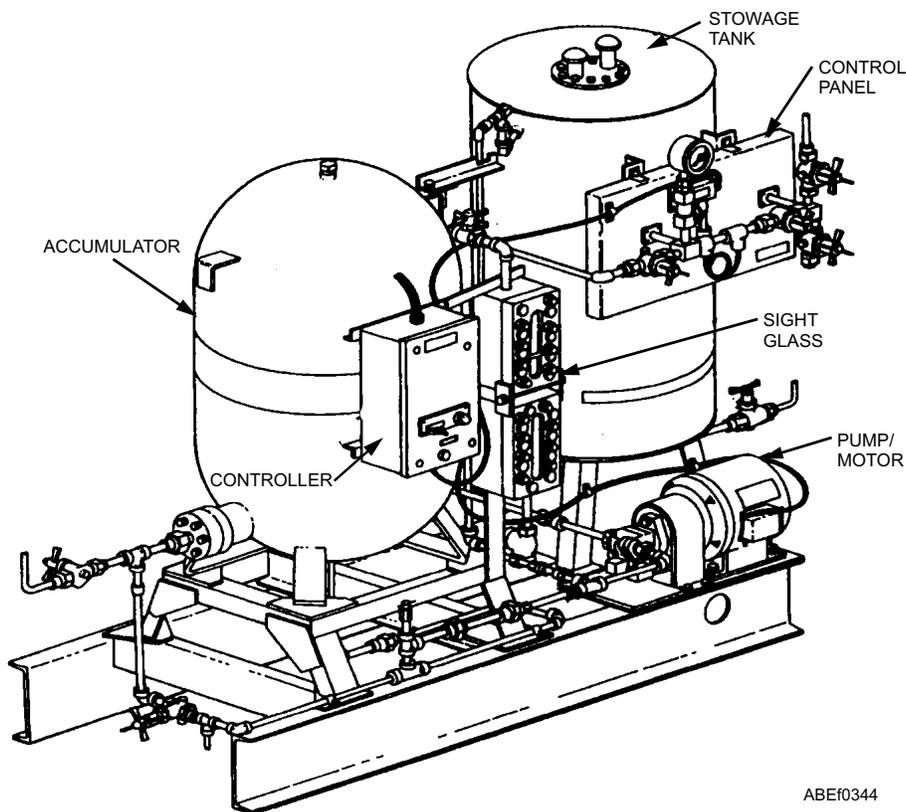
individual springs (4) each. It is designed to act as a single spring by means of rods (3) that pass through each set of springs and end in eyed terminals (6). The inboard ends of the rods are bolted to clevises (2), which are welded to an equalizing plate (1). The plate has a threaded adjustable rod that is secured to the ship's structure to hold the inboard ends of the spring unit.

The outboard ends of the rods are bolted to a similar plate, which has a welded clevis outboard, through which is bolted the eyed terminal of the counterbalancing spring cable. The cable (7) runs through two sheaves and is then bolted through its terminal to the actuator arm of the barricade stanchion, below the point of attachment for the cylinder.

When the stanchion is lowered by the cylinder, the sets of springs are uniformly compressed and resist the force of the descent, and cushions its fall against the deck. Raising the stanchion slackens the spring cable and decompresses the spring, but this release of compression has no appreciable effect on raising the stanchion.

### STANCHION LATCH

Stanchion latches are used to secure the stanchions to the deck in their DOWN position. Stanchion latches (fig. 3-43) are spring-loaded latches bolted to the subdeck and provided with a slotted frame, designed to allow the latch (5) to be retracted against the force of a spring (2), and turned to lock the latch open. When the stanchion is lowered, the latch may be engaged in a hole provided in the stanchion, and a spring will hold the latch in.



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Figure 3-44.—Barricade power package.

## POWER PACKAGE

The power package (fig. 3-44) provides and maintains the fluid pressure required by the hydraulic cylinders to raise and lower the barricade stanchions. It consists of a base weldment, gravity tank assembly, control panel assembly, accumulator, motor controller, pump, electric motor, electrical system, and piping system.

The gravity tank assembly has a capacity of approximately 125 gallons and is the fluid reservoir in the power package assembly. Displaced fluid from the cylinder assemblies is returned to the gravity tank, and from there it is pumped back to the accumulator. The gravity tank is welded steel, closed at the top and bottom by flat plates. The top cover plate has an access hole, which is covered by a cap plate and gasket held in place by bolts. Tapped bosses welded to the cap plate are for breather vents. A liquid-level gauge is connected to the side of the gravity tank. An indicator plate is attached to the tank at the level gauge to show the proper fluid level.

The control panel assembly (fig. 3-45) is attached to the gravity tank by four bolts.

The panel consists of the panel frame (1), two piping support brackets (9), accumulator pressure gauge (6), pressure sensing switch (7), gauge valve (3), air-charging valve (5), vent valve (2), air supply valve (4), caution plate (8), and operating instruction plate (10). Necessary copper tubing and sil-braze fittings connect the panel to the accumulator assembly, to a ship's exhaust line, and to the ship's high-pressure air supply line. The accumulator pressure gauge (6) is used to indicate pressures ranging from 0 to 2,000 psi in the accumulator.

The pressure-sensing switch (7) is a piston type, contained in a splashproof housing. It is connected to the pressure line from the accumulator with a threaded adapter and a coil of tubing between the adapter and tee in the pressure line. The function of the pressure-sensing switch is to maintain accumulator pressure between 1,250 psi and 1,500 psi. It does this by opening or closing to stop or start the pump motor.

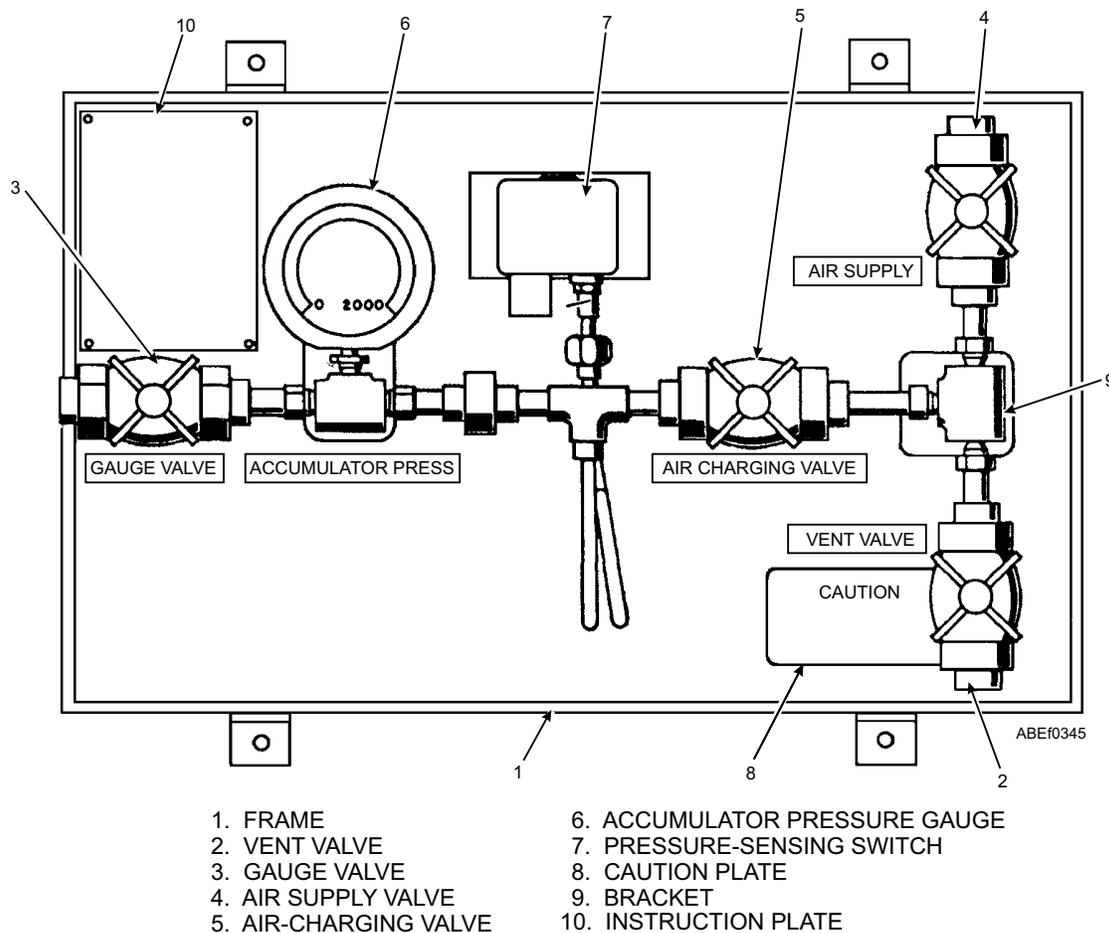


Figure 3-45.—Control panel assembly.

The pressure switch operates only when the motor controller switch is set at the AUTOMATIC position. The caution plate (8) is located next to the vent valve (2). It cautions all concerned to keep the vent valve open at all times except when charging the accumulator, and contains instructions for closing the vent valve when charging the accumulator.

A gauge valve (3) is furnished to maintain pressure in the accumulator when it is necessary to remove the pressure gauge (6). The air-charging valve (5) regulates the charging flow. The air supply valve (4) controls the flow intake of air to the control panel and accumulator. The operating instruction plate (10) contains basic operating instructions and a piping schematic.

The motor controller regulates the starting and stopping of the pump motor in conjunction with the pressure-sensing switch. The controller, operating magnetically, provides a switch control for OFF, AUTOMATIC, or RUN positions. The OFF position is used when the power package is secured. The AUTOMATIC position is used when the power package is to be operated, and the RUN position is used when it is necessary to bypass the pressure-sensing switch. Protective features of the controller include pilot circuit and motor overload protection and undervoltage release. A white light is mounted on the controller to indicate when power is available. When the switch is in the OFF position, the circuits from the controller to the motor and the pressure-sensing switch remain open, or dead. In the AUTOMATIC position, the motor starts when the contacts are closed in the pressure-sensing switch, and the motor stops when the contacts open. The RUN position is spring returned, and the motor runs only as long as the switch is manually depressed.

In the piping system, manual valves are placed in the lines to provide for operating and standby conditions and for maintenance. Each valve is tagged with a nameplate giving its number and normal operating position (OPEN or CLOSED). Miscellaneous equipment includes a check valve, fluid strainer, hydraulic pressure relief valve, and an air safety head. The check valve between the accumulator and pump prevents fluid pressure from backing up to the pump. The fluid strainer in the line between the gravity tank and the pump removes foreign matter before it enters the pump. The hydraulic relief valve connected to the line between the check valve and pump provides for pressure relief. The hydraulic relief valve is adjusted to crack open at 1,600 psi (minimum)

and open full at 1,750 psi. This line is equipped with a liquid sight indicator for visual checking of fluid flow, which would indicate an open relief valve. The air safety head, which ruptures at approximately 2,000 psi, is connected to the air line between the accumulator and control panel. It acts as a safety to prevent charging the accumulator and related components above their design limits. Two breather vents at the top of the gravity tank provide for passage of air out of or into the tank as the liquid level rises or lowers. A screen in the breather vent removes any foreign matter from incoming air.

## **BARRICADE OPERATION**

During normal operations the system is put in the READY condition. The power package, which is located below deck and includes an accumulator and gravity tank, is to be placed in a READY condition as follows:

- Place accumulator pressure at 1,500 psi.
- Fill accumulator and gravity tank liquid to operating level.
- Open or close proper valves.
- Place motor controller switch on AUTOMATIC.
- Check controls for proper operation.
- Inspect barricade-tensioning pendants for fraying.

As shown in figure 3-46, after the latch at the top of the stanchion is released, the deckedge control valve lever is placed in the Raise position (No. 1), and the stanchions will raise simultaneously. Raising operations may be stopped and stanchions held in any position by placing the deckedge control valve lever in the Neutral position (No. 2).

To lower the stanchions, place the deckedge control valve lever in the Lower position (No. 3). Stanchions will lower simultaneously. Lowering operations may be stopped and stanchions held in any position by placing the deckedge control valve lever in mid-position (No. 2).

The deckedge control valve lever in mid-position (No. 2) is the standby position. It blocks all valve ports, and any passage of fluid is stopped when the valve is in this position. This position should be used to stop stanchions during raising or lowering or to hold the stanchions either up or down.

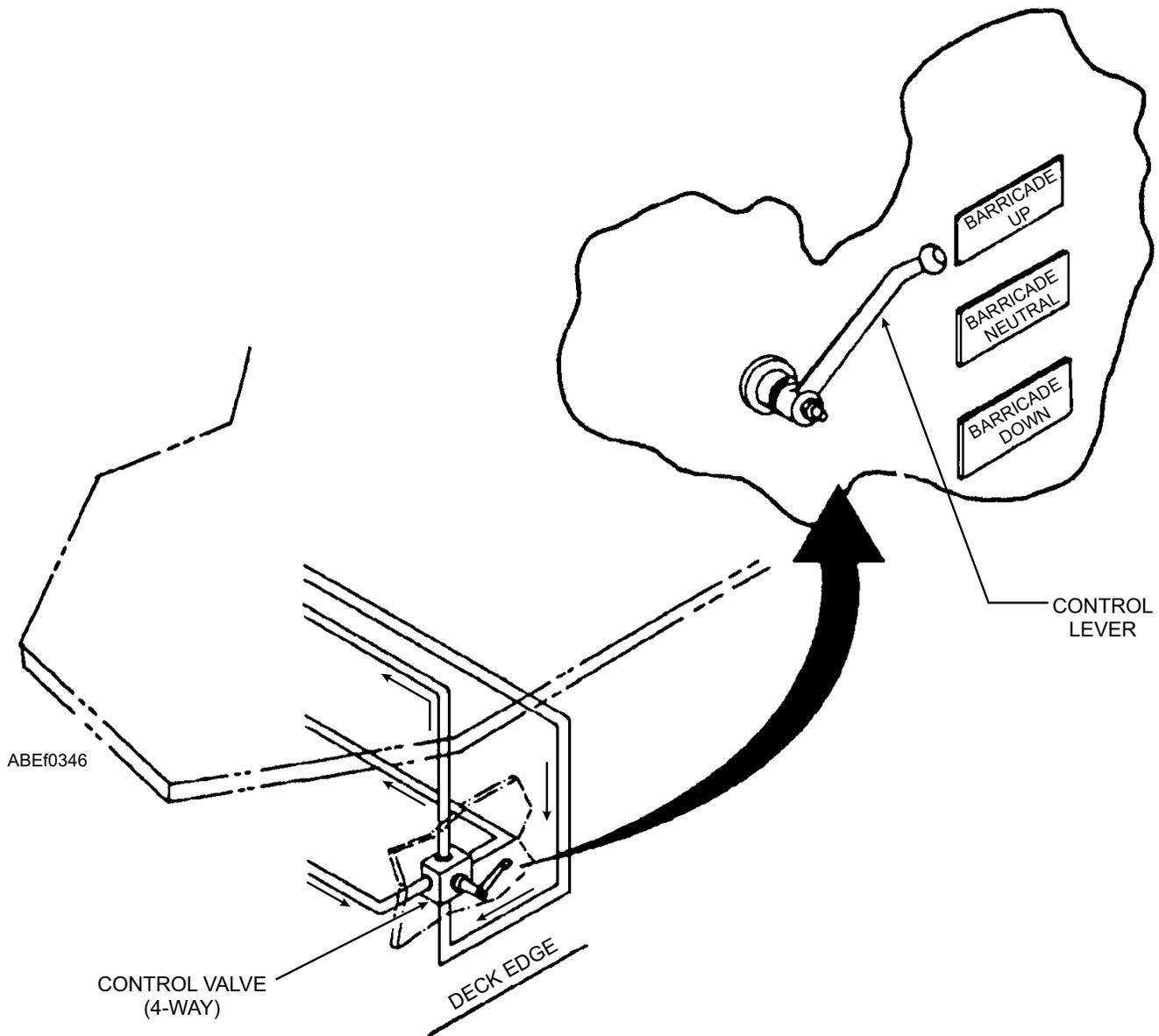


Figure 3-46.—Barricade stanchion controls.

**CAUTION**

The control valve lever must never be held or left in any position between 1 and 2 or 2 and 3, since this allows fluid to drain from the accumulator, through the system, to the gravity tank.

The power package accumulator does not contain sufficient fluid to raise and lower the stanchions more than three times without the pump operating. Approximately 20 minutes is required for the pump to replenish fluid to the operating level in the accumulator, if stanchions are cycled three times without the pump operating. The READY CONDITION for normal

operation specifies 1,500 psi accumulator pressure; however, stanchions will raise and lower, taking a longer period of time with a lower pressure, as is experienced if stanchions are cycled without the pump operating. Pressure at the start of the third cycle will be approximately 850 psi without the pump operating.

If the stanchions are cycled more than three times without the pump operating, air will enter the piping and cylinders, and fluid will overflow the gravity tank. It is then necessary to fill, vent, and charge the system as specified in the applicable operating manual.

During the READY and SECURE conditions, the following checks are to be made:

During the READY condition at 1-hour intervals, check the accumulator pressure, accumulator and gravity tank liquid levels, controller switch for AUTOMATIC setting, and make sure the pump is not operating when accumulator pressure is 1,500 psi or above.

During the SECURE condition, make a daily check of the accumulator pressure, accumulator and gravity tank liquid level, valves for position (open or closed), and controller switch for OFF setting.

The system must be operated WEEKLY to raise and lower the stanchions, to vent air from both ends of the hydraulic cylinders, and to check the operations of the system. It is not necessary to attach the barricade webbing during this exercise.

### REVIEW QUESTIONS

- Q7. List the four differences between a pendant engine and a barricade engine.*
- Q8. What connects the upper and lower loads straps to the barricade stanchions?*
- Q9. When are the counterbalancing springs compressed?*
- Q10. What secures the barricade stanchions to the deck?*
- Q11. What is the barricade power package accumulator operating pressure?*
- Q12. What are three positions of the motor controller switch?*

### MAINTENANCE PROCEDURES

**LEARNING OBJECTIVES:** Describe the procedures for replacing purchase cables. Describe the procedures for replacing packings.

Arresting gear must be kept ready for instant use. There is only one way such a condition may be effected; that is, by constant inspection, repair, and maintenance. Preoperational and postoperational inspection of all components is mandatory, as directed by the applicable MRC. Every section, topside, below deck, engine areas, and ready stowage must be prepared to function on command.

Maintenance can be divided into two broad categories: preventive maintenance and corrective maintenance. Preventive maintenance consists of routine shipboard procedures designed to increase the

effective life of equipment or to forewarn of impending troubles. Corrective maintenance includes procedures designed to analyze and correct material defects and troubles. The main objective of shipboard preventive maintenance is the prevention of breakdown, deterioration, and malfunction of equipment. If, however, this objective is not reached, the alternative objective of repairing or replacing failed equipment—corrective maintenance—must be accomplished.

Maintenance by the arresting gear crew must go beyond a wipedown and periodic lubrication. The arresting gear personnel must be instructed to alert the officer in charge to any signs of malfunction, wear, looseness, leakage, damage, or any other irregular conditions in the arresting gear equipment. They should also learn the physical location of all operating parts, cable runs, air supply lines, valves, electrical supply lines, switches, fuse boxes, tools, and spare parts.

Engine inspection should be visual, mechanical, and operational. The following general notes apply to maintenance throughout the arresting gear equipment:

- Mechanical inspection is performed while the engine is at rest. It consists of a security check, exercising the engine, and manipulating the controls. This inspection is a check for looseness, excessive play, improper operation of hidden parts, lack of lubrication, or any abnormal resistance to motion.
- Operational inspection consists of running all operable systems through a full cycle of operation, checking for smoothness of operation, proper timing, and synchronization.
- All maintenance performed on recovery equipment should be noted in the maintenance log for that particular unit.
- Changes in critical measurements should be logged so that they can be used to predict trends and avoid possible troubles.
- Wipe down all arresting gear equipment daily to remove dirt and grime.
- Remove rust; paint when necessary.
- Do not paint threads or finished machined surfaces.
- Check for loose or damaged bolts, nuts, and screws. Tighten or replace as required.

Replacement bolts should be of equal or greater strength than the original.

- All bolts should be tightened to the proper torque value.
- Check for hydraulic and pneumatic leaks.
- Be alert for any unusual sounds that may indicate malfunctioning equipment. Report these conditions to the officer in charge.
- Check spares on hand against allowable spares list. Replenish spare parts monthly.
- Maintenance personnel must establish and carefully maintain the Recovery Wire Rope History Chart, recording all wire rope data.
- The replacement of any O-ring, V-ring, or other pressure seal necessitates a high-pressure test of the equipment before resuming arresting operations. Before you can pressure test newly installed seals, it is necessary that the unit stand for a period of 1 hour before the seals can be accepted.

Once each year (or as modified by appropriate technical publications), drain the ethylene glycol from the system and replace with fresh fluid.

## **REPLACING PURCHASE CABLES**

During recovery operations, malfunctions may develop in the engine and cable system, causing the purchase cable to pull out of the sheave arrangement or break below deck, close to or at the engine, resulting in shutdown of the system. Also, conditions occur in which initial reeving of the engine is necessary or old purchase cable is required to be replaced by new purchase cable. Any or all of these conditions can occur on single or endless reeved engines.

If the old cable is still reeved, do not pull it out. When possible, the old cable should be used to pull in the new. Even if the old cable is only partially reeved, it will prove useful. Reeving is very much simplified if cable already reeved in the proper way can be used. A decision must be made for each particular engine as to whether it is easier to feed the new cable from the engine and pull from the flight deck level with a tractor, or feed from the flight deck and pull from the engine with block and tackle. In either case, the cable should be pulled very slowly, and communication should be maintained between engine and flight deck, so that the pulling can be stopped quickly if there is danger of

pulling a kink into the line. If the purchase cable is severed below deck but still reeved, isolate the break and thread a 9/16-inch cable through the system and butt braze this to the longer length to provide a continuous line for pulling in the new cable.

The following procedures should be followed in replacing purchase cables:

1. Initial reeving of an engine is facilitated by hand-threading the complete fairlead system and engine with a length of 9/16-inch cable. After reeving the 9/16-inch cable, splice and braze the end to the purchase cable and pull the larger into the system with the smaller. This smaller-diameter cable is easier to push through the fairlead pipes and wrap around the sheaves before pulling in the purchase cable.
2. To thread the cable through the deck and fairlead sheaves, remove the sheave covers and pull out the sheaves. Push the cable through the fairlead pipes from sheave housing to sheave housing. Then slip the cable into the sheave groove as the sheave is replaced in the housing. When the cable is fully threaded, replace the covers.
3. In reeving the engine, use only the original, approved reeving pattern. Study the reeving diagram in the applicable NAVAIR maintenance manuals, and be careful to pass the cable over the sheaves in the approved sequence and through the appropriate fairleads and guides.
4. After the cable is reeved, the next step is to connect the anchor end of each length. Then the cable must be stretched taut to determine the correct location for the terminal of the opposite end.

New cables acquire a stretch over the course of the first several engagements. This lengthening of cables decreases the distance between crosshead and crosshead stop in the BATTERY position, and this in turn increases the fluid capacity of the hydraulic system and makes it necessary to add fluid to maintain the fluid level. If the distance from crosshead to crosshead stop in the BATTERY position becomes less than the minimum allowable clearance of 1 inch between the crosshead and the crosshead stop, it becomes necessary to crop the cable and repour a terminal to readjust the clearance to 6 inches between the crosshead and the stop. The clearance between the crosshead and crosshead stop with newly installed purchase cables is

set at 7 inches. New purchase cables will stretch very rapidly during the first few arrestments. The initial 7-inch dimension between the crosshead and the stop allows for this structural stretch, which causes a progressive narrowing of the gap distance between the crosshead and crosshead stop. After the purchase cable has been stretched and reaches the minimum allowable clearance of 1 inch between the crosshead and crosshead stop, a 6-inch dimension is used thereafter.

When it becomes necessary to rereeve a single-reeved engine, both purchase cables must be replaced. Reeving only one purchase cable on a single-reeved engine result in unequal length of the two cables, because of the initial stretch of the new cable. An offcenter deck pendant is an indication of one cable stretching more than the other. This condition could cause one of the purchase cable terminals to rest in the deck sheave. To correct this condition, you will have to crop the longer cable and repour the terminal.

During arrestment operations, torque builds up in the purchase cables. Failure to remove this torque results in accelerated wear and bird-caging of the cables, with vastly increased susceptibility to failure. Compliance to detorquing methods at specified intervals is mandatory. Newly installed purchase cables should be detorqued after the initial 50 landings (no more than 60) and every 200 landings thereafter.

### **WARNING**

Keep hands free of spinning parts when releasing torque from cables.

Purchase cable torque can be removed in the following ways. During flight operations, disconnect one side of the crossdeck pendant at the completion of an arrestment and partially retract the engine. This allows the cables to untwist. If time allows, blow the engine down to 200 psi and pull the engine out to its full stroke; disconnect one side of the crossdeck pendant; and retract the engine slowly to approximately 20 feet out of battery.

If torque buildup is greater than normal, it is recommended that the crossdeck pendant be discon-

nected from both topside terminals to allow a more efficient detorque of the cable system.

### **Preparing Cable and Terminal for Pouring**

When working around an arresting gear engine, make sure the arresting engine retracting system is depressurized before performing any of the following steps involving the handling of the wire rope.

### **Preparing Wire Rope**

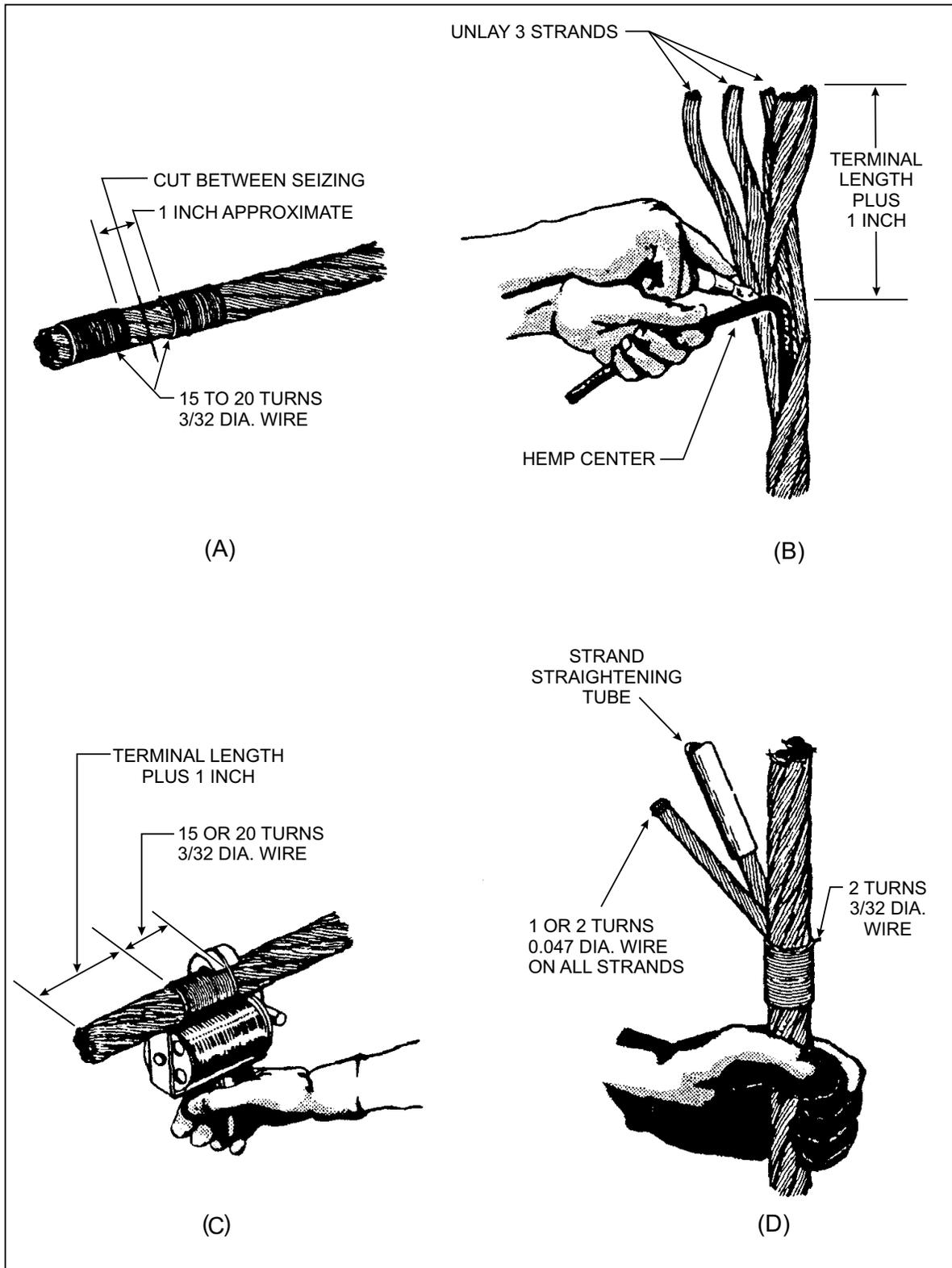
When it is necessary to cut the wire rope, place two seizings of approximately 15 or 20 turns of soft steel seizing wire on the cable, approximately 1 inch apart. (See fig. 3-47, view A.) Cut the cable between the two seizings.

Remove the seizing from the cut end of the cable and, with the use of a marlinespike, unlay three strands of the cable. Using a pocketknife, cut and remove the hemp center a distance equal to the length of the terminal plus 1 inch. (See view B of fig. 3-47.) Re-lay the strands of the cable.

Make a seizing a distance equal to the length of the terminal plus 1 inch. The seizing should be made with the use of a serving tool and be 15 or 20 turns of soft steel seizing wire. (See fig. 3-47, view C.) Place two wraps of seizing wire immediately above the large seizing, as shown in view D.

Loop and tighten one or two turns of 0.047-inch-diameter copper wire on the end of all strands, as shown in view D. Using a marlinespike and tubing, unlay and straighten the strands of the cable to the top of the seizing. Pull the strands in toward the center to ensure a good distribution when the individual wires of each strand are straightened. (See view D of fig. 3-47.) After all the strands are straightened, remove the two turns of seizing previously placed at the top of the large seizing. Do NOT remove the large seizing; this seizing remains in place until pouring procedures are completed.

Do NOT use pliers to straighten the wires; pliers may damage or weaken the wires.



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Figure 3-47.—Wire rope preparation.

Make certain that the large seizing is tight; remove the copper wire seizing from one strand at a time, and straighten the individual wires, using the power straightening device, shown in figure 3-48.

Repeat the straightening procedure on each strand, working on one strand at a time, until all the wires are completely broomed out as shown in figure 3-48.

### Cleaning Wire Rope and Terminal Pouring

The cleaning and preparation of wire rope and terminals requires the use of chlorinated degreasing solvents, grit blasting, and the heating and melting of zinc.

#### WARNING

Personnel cleaning wire rope and pouring terminals must use chemical respirators and

make sure the area is properly ventilated. For complete safety procedures concerning zinc terminal pouring and wire rope preparation, consult the current arresting gear NAVAIR operation, maintenance, and overhaul instructions.

In a well-ventilated space, prepare the ultrasonic degreaser unit by filling it with GRISOLVE PEG-2, to within 1 inch of the tank top. The ultrasonic degreaser must then be energized for 2 hours before degreasing operations begin; this degasses and removes oxygen from the solvent, which increases its cleaning ability. One hour before the degreasing operation is to start, turn on the ultrasonic unit's heaters to heat the GRISOLVE PEG-2 to a temperature of 90 to 100°F. A stainless steel bucket (14-quart) will also be filled with 3 gallons of GRISOLVE PEG-2; this is used to rinse the broomed cable end after it has been cleaned in the ultrasonic degreaser unit.

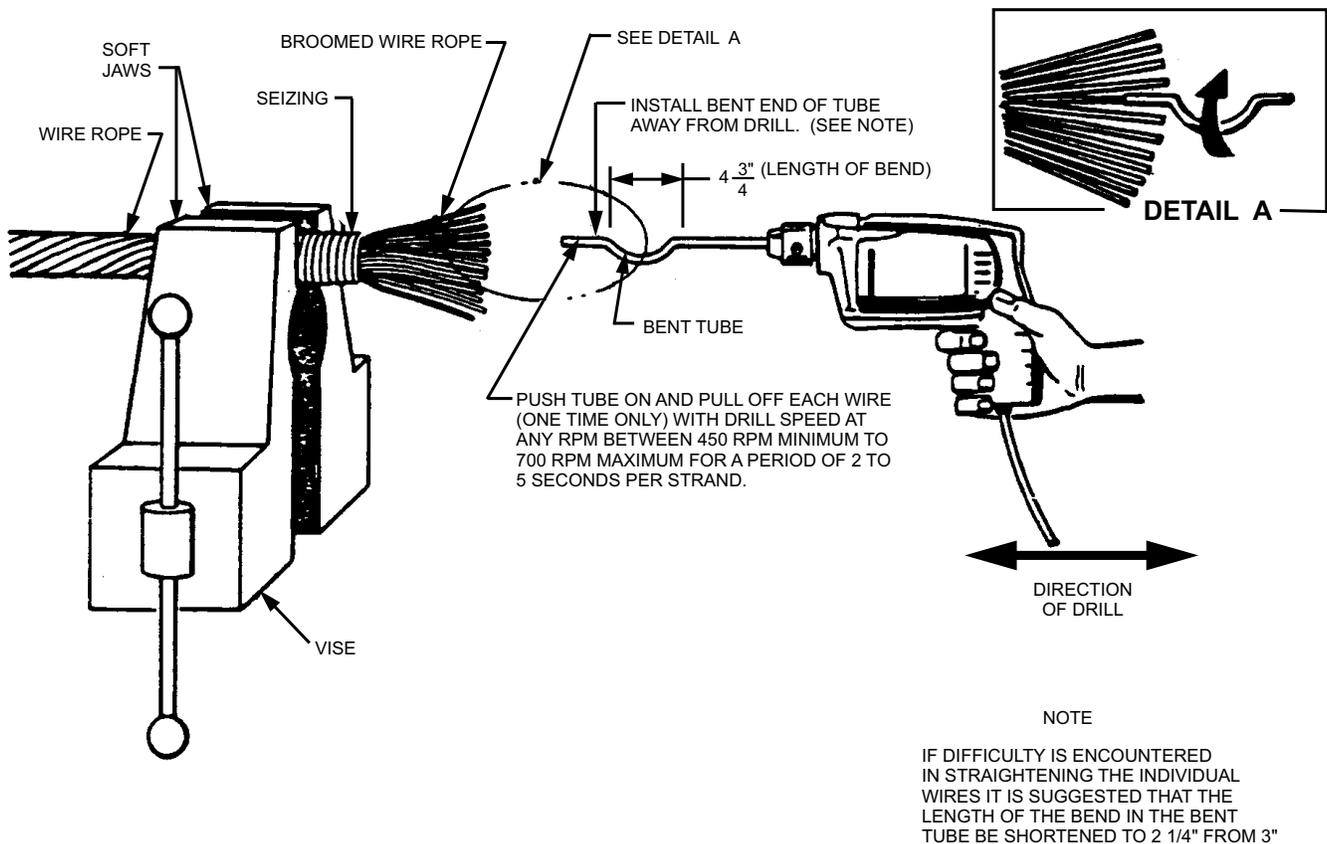
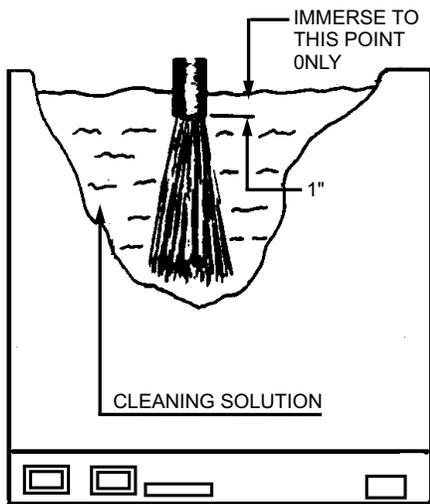


Figure 3-48.—Straightening individual wires with power straightening device.

ABE0348



CLEANING SOLUTION



RINSING SOLUTION



(1) ULTRASONIC DEGREASER (P/N 521566-1). IMMERSE THE BROOMED WIRE ROPE IN DEGREASING SOLUTION, GRISOLVE PEG-2 OR IMPACT INDUSTRIAL, (REPLACE DEGREASING SOLUTION EVERY 10 USES.)

(2) RINSE BROOMED WIRE ROPE IN 14 QT CONTAINER FILLED WITH 3 GALLONS OF GRISOLVE PEG-2 OR IMPACT INDUSTRIAL DEGREASING SOLUTION.

(3) DRAIN AND AIR DRY FOR FIVE MINUTES IN DOWN POSITION.

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Figure 3-49.—Cleaning broomed-out wires.

To degrease, immerse the broomed end and approximately 1 inch of the seizing into the solvent in the ultrasonic degreaser unit tank (see fig. 3-49).

- The cleaning solution must be changed after 10 uses.
- Replace the rinsing solution when it becomes cloudy.

After cleaning the broomed end, slowly lift it out of the solution, allowing it to drain over the tank. Now, rinse the broomed end in the bucket of clean GRISOLVE PEG-2 then remove it and allow it to air-dry for 5 minutes as shown in figure 3-49. After the broomed end has dried, inspect it to ensure that all dirt, grease, and all other foreign matter have been removed. If necessary repeat the cleaning/degreasing operation. Following degreasing, the cleaner residues must be rinsed from the wire broom. Heat a 3-gallon bucket of clean, potable water to a temperature of 160° to 200°F. Immerse the broom in the rinse bucket of hot water until half of the seizing is immersed. Allow the broom to rinse for 2 or 3 minutes, gently swirling the terminal to agitate the water. Remove the terminal from the water and shake off the excess.

Following the rinse, examine the broom for any preservative remaining on the wires, especially where wires touch. If preservative accumulations are still apparent, reimmerse the broom into the degreaser,

repeat this cycle using clean rinse water each time until the broom appear clean.

After the broomed out wires have been thoroughly cleaned, wrap the end of the wire rope with two longitudinal strips of pressure-sensitive tape for a distance of 2 feet, leaving the broomed out wires and 1/2 inch of the seizing exposed (fig. 3-50).

The method used in preparing wire rope and terminals for zinc-poured terminals includes a grit blast method for etching the cables and terminals prior to pouring.

The following steps are used in the grit blast method:

1. Fill the cabinet hopper with loose grit, 100 pounds minimum to 200 pounds maximum.
2. Install the applicable inserts in the cabinet, depending on the size of the purchase cable being cleaned.

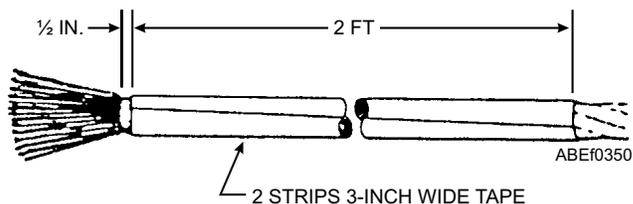


Figure 3-50.—Adhesive cloth tape applied to wire rope.

- Open the door of the grit blast cabinet by holding two thumbscrews and lifting. Place the prepared end of the wire rope into the grit blast cabinet to a convenient working location. Support the wire rope externally so that it enters horizontally. Secure the door with the wire rope in position. The wire rope should fit snugly. If the inserts used do not effect a snug fit, apply tape or cloth to that area of the wire rope.

An 80-100 psi dry-air source must be connected to an air filter located in the grit blast cabinet. Turn on the air source when ready to blast the wire rope.

- With hands in the gloves of the cabinet, grasp the blasting gun in one hand; and with the other hand, hold the siphon tube 1 inch or more below the surface of the grit. See figure 3-51.
- Blast the broomed-out wires with the gun nozzle tip 1/4 inch away from the wires. Use a back and forth motion over the entire length of exposed broomed-out wires, from the top of the wires to the bottom of the wires. Continue until a dull nonreflective surface appears on the wires. Rotate the wire rope 90°, using the applicable twisting wrench. See figure 3-52.

NOTE: If during the grit blast operation the gun becomes clogged, it may be necessary to sift foreign matter from the grit. This is accomplished by using a sieve furnished with the grit blasting cabinet.

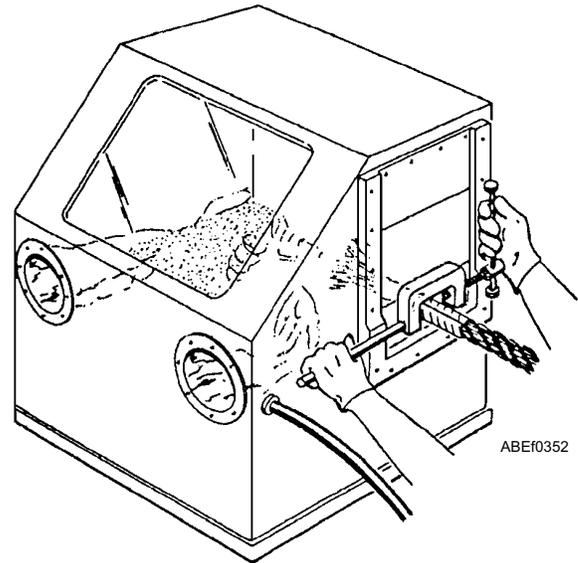


Figure 3-52.—Rotating the cable in the grit blast cabinet.

- Repeat the process until the entire exposed area of wire rope has been grit blasted. Finally, direct the nozzle into the open end of the broomed-out wires at about 30° from the longitudinal, and rotate the wire rope slowly through 360° while blasting with a circular motion. See figure 3-53. Remove the wire rope from the cabinet and inspect it for completeness of grit blasting. Any evidence of shine will indicate a need for additional grit blasting. After being grit blasted, the wires should not be touched with hands, rags, gloves, and so on, or the cleanliness required for sound terminals will be impaired.

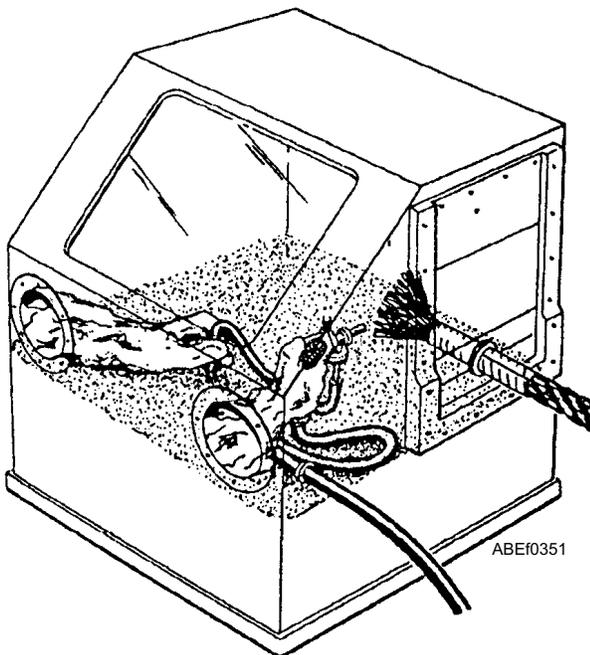


Figure 3-51.—Grit blasting of wire rope.

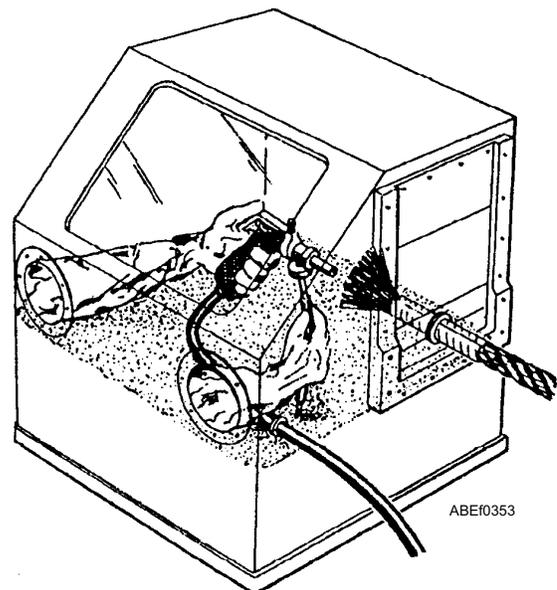
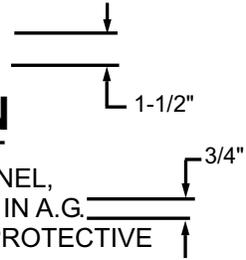


Figure 3-53.—Blasting inner wires.

## **WARNING-DANGEROUS AREA** **PROVIDE ADEQUATE VENTILATION**

WHEN POURING TERMINALS, ONLY AUTHORIZED A. G. PERSONNEL, FOLLOWING THE PROPER POURING INSTRUCTIONS OUTLINED IN A.G. MANUALS AND LATEST BULLETINS, AND WEARING SPECIFIED PROTECTIVE GEAR, ARE PERMITTED IN POURING ROOM/AREA.



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Figure 3-54.—Safety placard for terminal-pouring rooms.

7. Shake the wire rope vigorously, broomed-out end down, to remove any grit between the wires or in the hemp center. Only air from the cabinet supply is used to remove grit; do NOT use any other source, because other sources may be contaminated with oil or water.
8. Remove the grit-siphon tube from the grit supply, and air blast the wire rope to remove the remaining grit.

NOTE: After grit blasting a total of 15 broomed-out ends, drain off 10 pounds of used grit from the bottom of the hopper and replace it with 10 pounds of new grit.

9. Remove the tape from the wire rope.
10. Prepare a solution and flux the wire rope.

### **Fluxing**

For solution preparation and fluxing, the following procedures are used:

1. Heat the pre-mixed solution until the temperature is between 160 and 210°F, using the hotplate provided. Measure the temperature of the solution with the bimetallic thermometer. Allow the solution to remain at this temperature for 5 minutes, then remove it from the hotplate and allow it to cool to room temperature.
2. Remove any scum or foreign matter from the surface of the cooled solution with clean napkins or wiping towels. Do NOT agitate the solution during this operation.
3. Carefully pour the clear, cooled solution into another stainless steel container. Avoid pouring any foreign matter into this container. If the hot-air drying method is used, the solution can

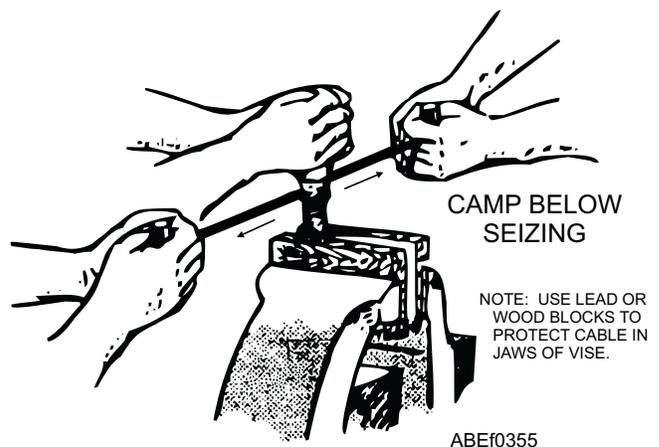
be used cold. If the cable is to be dried by natural air, use the procedures listed in step 4.

4. Heat the clear flux solution until the temperature is between 160 and 210°F. Immerse wires carefully so the flux solution does not enter the core of hemp-center-type wire rope.

### **WARNING**

Do NOT flux wire rope terminals.

5. Immerse the grit-blasted wires in the solution to within 1 inch of the top of the seizing for 5 minutes.
6. Remove the wire rope from the solution, shake, and turn the broomed end upright at once. Then allow it to dry for 5 minutes. Any evidence of rust on the wires after the flux-dry period will necessitate refluencing.



INSTALLING TERMINAL ON BROOMED END OF WIRE

Figure 3-55.—Installing the terminal.

## Preparing the Terminals

Using a degreased length of seizing wire, suspend the terminal from the top of the ultrasonic degreaser so it is submerged in the solution. Inspect the terminal and repeat the procedure if necessary. Rinse the terminal in a bucket of clean GRISOLVE PEG-2 for 30 seconds, then let air-dry for 5 minutes.

Replace the solution in the ultrasonic degreaser after 10 terminals have been cleaned/degreased. Replace the rinsing solution after 10 terminals have been rinsed or as soon as the solution becomes cloudy.

Lay the terminal in the grit blast cabinet. Plug the cable entry hole with the rubber plug hanging from the cabinet. Secure the doors on the side. Grit blast the internal surfaces of the terminal from both ends. Rotate the terminal so that the entire internal surface is blasted.

Remove the terminal, invert it, and shake it thoroughly to remove residual grit.

To keep arresting gear crews constantly aware of the health hazards associated with the present terminal pouring procedures, safety warning placards, fabricated by ship's forces, will be posted in clearly visible locations in the arresting gear terminal pouring rooms/area. (See fig. 3-54.)

## Preparing and Pouring Zinc

Make certain to use the special high-grade zinc ingot (NAEC PN323822-2), which comes in two-pound slugs. Personnel engaged in preparing and/or pouring molten zinc must wear protective clothing, such as goggles and gloves. A protective screen must be provided around the pouring station.

A ladle and heating furnace are used to melt the zinc. Use a ladle that is thoroughly dry and free from rust, scale, slag, or any other foreign matter. Place a minimum of five pure zinc ingots into a clean ladle.

The zinc must be heated to a range of 950 to 1,000°F for pouring. The temperature may not exceed 1,075°F. Discard zinc that has been heated above 1,075°F. Measure the temperature frequently with a portable pyrometer. Preheat the ladle prior to immersing it in the molten zinc.

Clamp the wire rope vertically, below the seizing, in a vise having copper- or lead-protected jaws. The wire rope should be clamped sufficiently tight to hold the wire firmly but not so tight as to deform the lay.

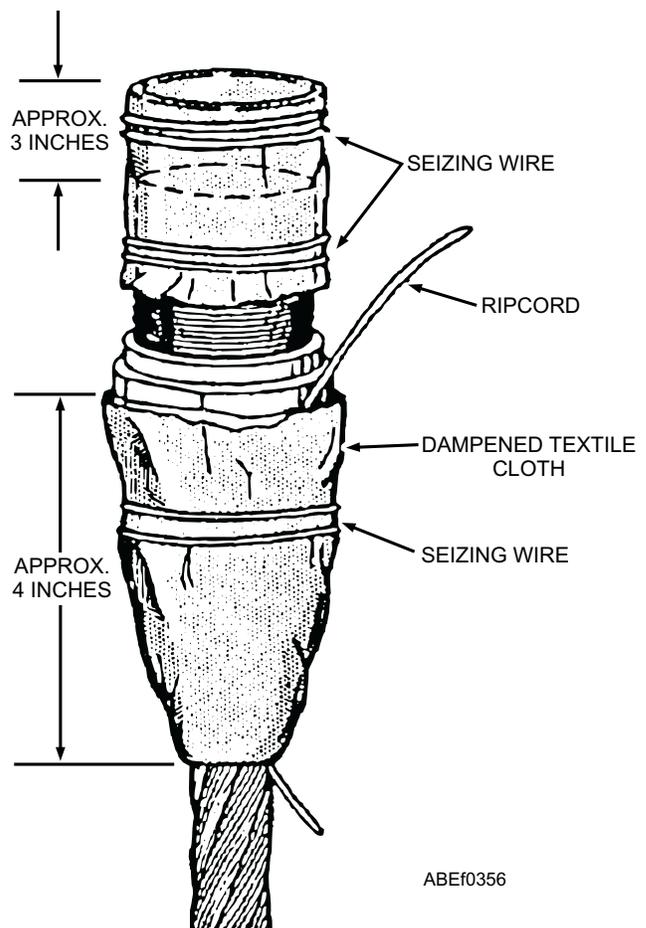
Attach wooden handles to each end of a length of soft steel wire that has been cleaned in the same way as the broomed-out cable and terminal. Loop this wire once around the broomed-out wires. Pull the wire to tighten the loop, and compress the broomed-out wires together. See figure 3-55. Do NOT touch broomed-out wires with greasy rags or hands.

Start the terminal on the compressed wires and slide it onto the wire rope until the bottom rests on the seizing. See figure 3-55.

Reclamp the wire rope in the vise in a vertical position. Make sure the terminal is not tilted in any way.

Degrease and secure two turns of copper wire around the broomed-out wire rope, 1/2 inch beyond the top of the terminal. Draw the broomed-out wires inward and away from contact with the terminal so that there is approximately 1/16-inch clearance between the wire and the inner wall of the terminal.

Wet a roll of plaster of paris bandage in lukewarm water and squeeze out the excess water. Wrap the plaster of paris bandage around the base of the terminal at a distance of about 4 inches. Press the bandage firmly to the contour of the terminal and wire rope. (See fig. 3-56.) Dampen a textile cloth with water and wrap it



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Figure 3-56.—Textile cloth applied to the terminal.

around the plaster of paris and secure it with seizing wire. The textile cloth may extend far enough to protect the wire rope from the torch while the terminal is being heated.

Heat the terminal carefully and uniformly with the torch, making certain the flame is not directed on the exposed wire rope at the bottom of the asbestos cloth. (See fig. 3-57.) Continue heating the terminal until it begins to radiate heat waves. Remove the torch from the terminal and leave the terminal undisturbed for 30 seconds. Make a mark on the thickest portion of the terminal with a 550 and 600°F Tempilstik. Repeat this at four areas, 90 degrees apart, to ensure an average temperature.

The zinc should be at the proper temperature at this time so that the pouring can take place when the terminal is heated to the correct temperature. Do NOT attempt to measure terminal temperature with the portable pyrometer.

If the 550°F Tempilstik leaves a wet mark and the 600°F Tempilstik leaves a chalk mark at the four areas, pour the zinc immediately. If the four areas show a wet mark for both the 550 and 600°F Tempilstik, continue checking the four areas every 20 seconds until the 600°F Tempilstik leaves a chalk mark and the 550°F Tempilstik leaves a wet mark; then pour the zinc immediately.

If the temperature has fallen below 550°F (550°F Tempilstik leaves a chalk mark), reheat the terminal and proceed again as previously described.

Skim the dross (impurities) from the top of the molten zinc before pouring. Use the portable pyrometer to measure the temperature of the molten zinc and to determine, thereby, if the zinc has reached its proper temperature for pouring. (See fig. 3-58.) The temperature of the zinc must be accurately measured with a portable pyrometer.

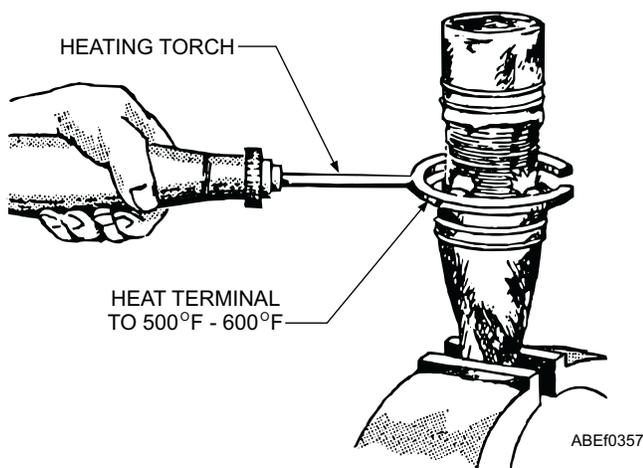


Figure 3-57.—Heating the terminal.

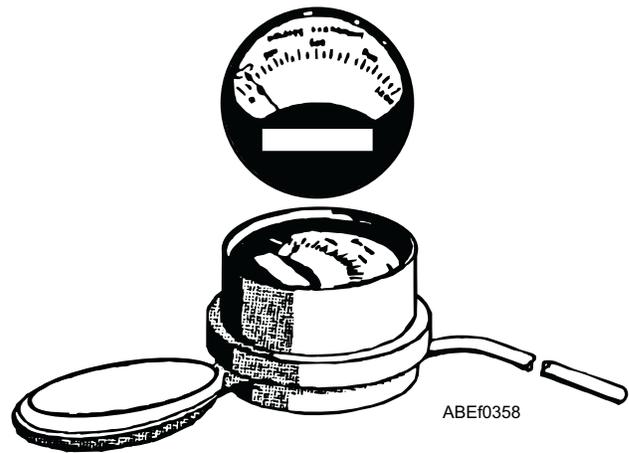


Figure 3-58.—Pyrometer.

Do not handle the portable pyrometer carelessly, because the millivoltmeter on it is a sensitive, precision instrument. When the portable pyrometer is not in use, keep it in the carrying case.

Measure the temperature of the molten zinc by holding the portable pyrometer in one hand and dipping the iron tube of the portable pyrometer in the molten zinc, being sure to keep the thermocouple in the center of the molten zinc and not touching the bottom of the pot. The temperature of the molten zinc will then be indicated on the portable pyrometer dial. Pour zinc at a temperature of 950 to 1,000°F.

Pour the zinc into the terminal. Fill it to within 1/2 inch from the top of the textile cloth to provide a sufficient "hot top."

Tap the sides of the terminal lightly with wooden sticks during and after pouring of the zinc, until a surface crust forms. See figure 3-59.

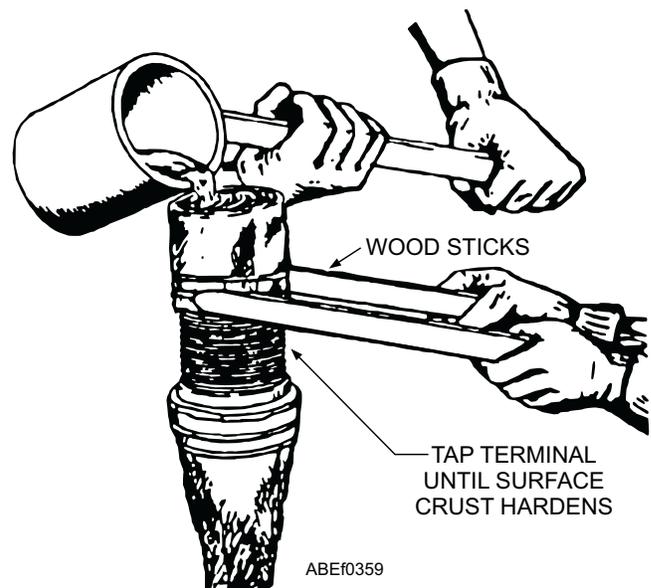


Figure 3-59.—Tapping the terminal during pouring.

Using a short piece of seizing wire thoroughly degreased, pierce the bubbles that rise to the surface of the hot top. Do not poke the wire into the zinc more than 1/2 inch. Skim the surface of the hot top with the end of the seizing wire to allow the gas bubbles to rise and be accessible for piercing.

After the zinc has solidified, allow the poured terminal to air-cool at room temperature for 30 minutes. During this time the zinc will harden. After the cooling period, proceed as follows:

1. Remove the textile cloth and plaster the terminal.
2. Pour 4 gallons of preservative oil into a clean 5-gallon metal container.
3. With the preservative oil at room temperature, immerse the entire poured terminal for 30 minutes. This will rapidly cool the terminal.
4. Immediately after the 30-minute oil quench period, remove the terminal and allow the excess oil to drain into the container.
5. Using the hot-top cutter assembly, cut off the hot top flush with the top of the terminal after the terminal has cooled (fig. 3-60).

### Finishing and Inspecting the Terminal

Round off the sharp edges of the terminal with a file. File the zinc down to a smooth surface flush with the end of the terminal. Clean the terminal with a wire brush. Remove all traces of residual flux, plaster, and superficial rust (using the wire brush) from the wire rope for a distance of 6 inches from the base of the terminal. Chase the threads with an applicable threading die.

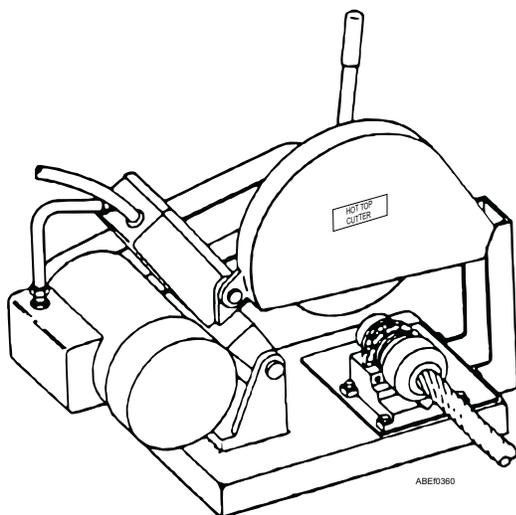
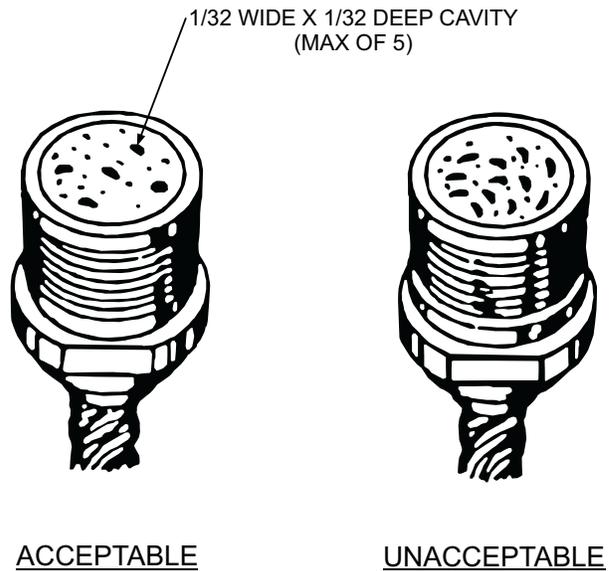


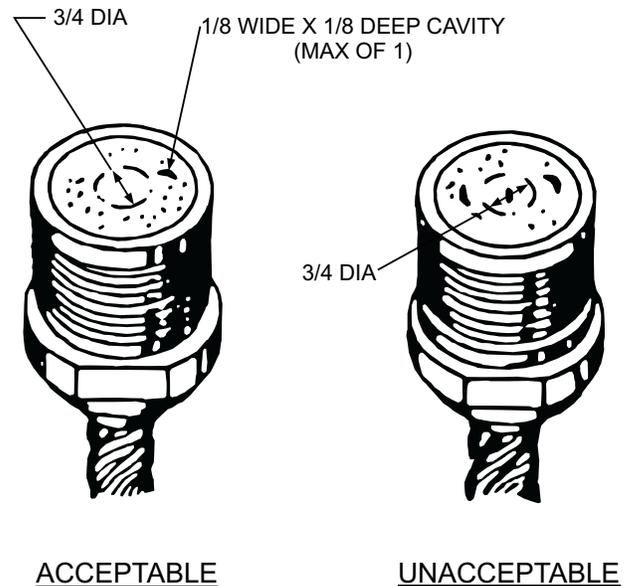
Figure 3-60.—Cutting the hot top.

Inspect the zinc face of the terminal for soundness of zinc and good wire distribution. The presence of any cavities in the face of the zinc indicates that the strength of the terminal is questionable. The criteria for acceptance of cavities are as follows:

1. A maximum of five cavities up to 1/32-inch wide and 1/32-inch deep scattered randomly over the zinc face. Figure 3-61, view A,



### CONDITION A



### CONDITION B

Figure 3-61.—Inspection of zinc face.

illustrates an acceptable face. Crop and repour if six or more cavities are found.

2. A cavity up to 1/8-inch wide and 1/8-inch deep caused by breaching of several wires must NOT be in the center of the zinc face within the area of 3/4-inch diameter. An acceptable face is shown in view B. A 1/8-inch cavity by 1/8-inch cavity caused by any other factor than breaching wires is not acceptable. This breaching is several wires coming together at the surface, which does not permit the zinc to fill the area. These allowable cavities are the result of pouring, and not that of a pull test.

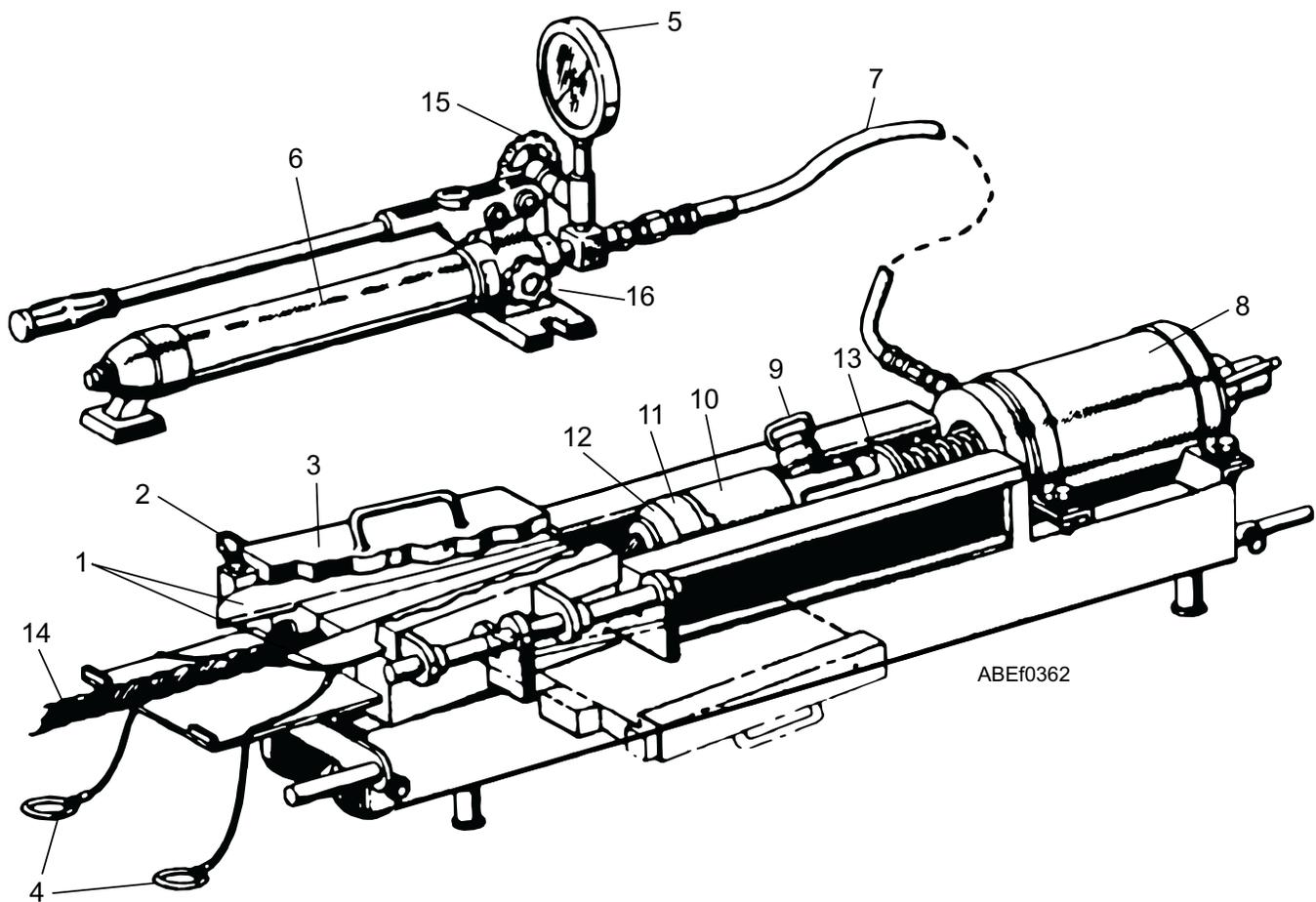
Inspect around the base of the terminal for a penetration of zinc. This penetration must be present to have an acceptable terminal. It is also a good indication

of a well-poured terminal. The wires of the strands of the wire rope below the terminal must not show any deformity due to having been held too tightly in the vise during the pouring and finishing operations.

### Testing the Terminal

During an arretment, the wire rope system must take a very high impact load; therefore, all fittings of the system must be carefully poured. It is imperative that the fitting be strong and well made. To determine their condition and strength, the terminals must be tested for soundness of the poured joint.

Terminals poured by a naval activity or by personnel aboard ship are tested for reliability. The cable terminal proof-loading machine is a self-



ABEf0362

- |                        |                                 |
|------------------------|---------------------------------|
| 1. Wedge set           | 9. Connecting pin               |
| 2. Safety lock pin     | 10. Clevis socket               |
| 3. Grip assembly lid   | 11. Lock ring                   |
| 4. Retracting cables   | 12. Cable terminal              |
| 5. Tension gauge       | 13. Tension rod                 |
| 6. Hand hydraulic pump | 14. Purchase cable              |
| 7. Hose assembly       | 15. Needle valve                |
| 8. Ram (cylinder)      | 16. External load release valve |

Figure 3-62.—Wedge-type proof-loading machine (single ram).

contained hand-operated unit designed specifically for proof loading poured terminals on both deck cables and purchase cables.

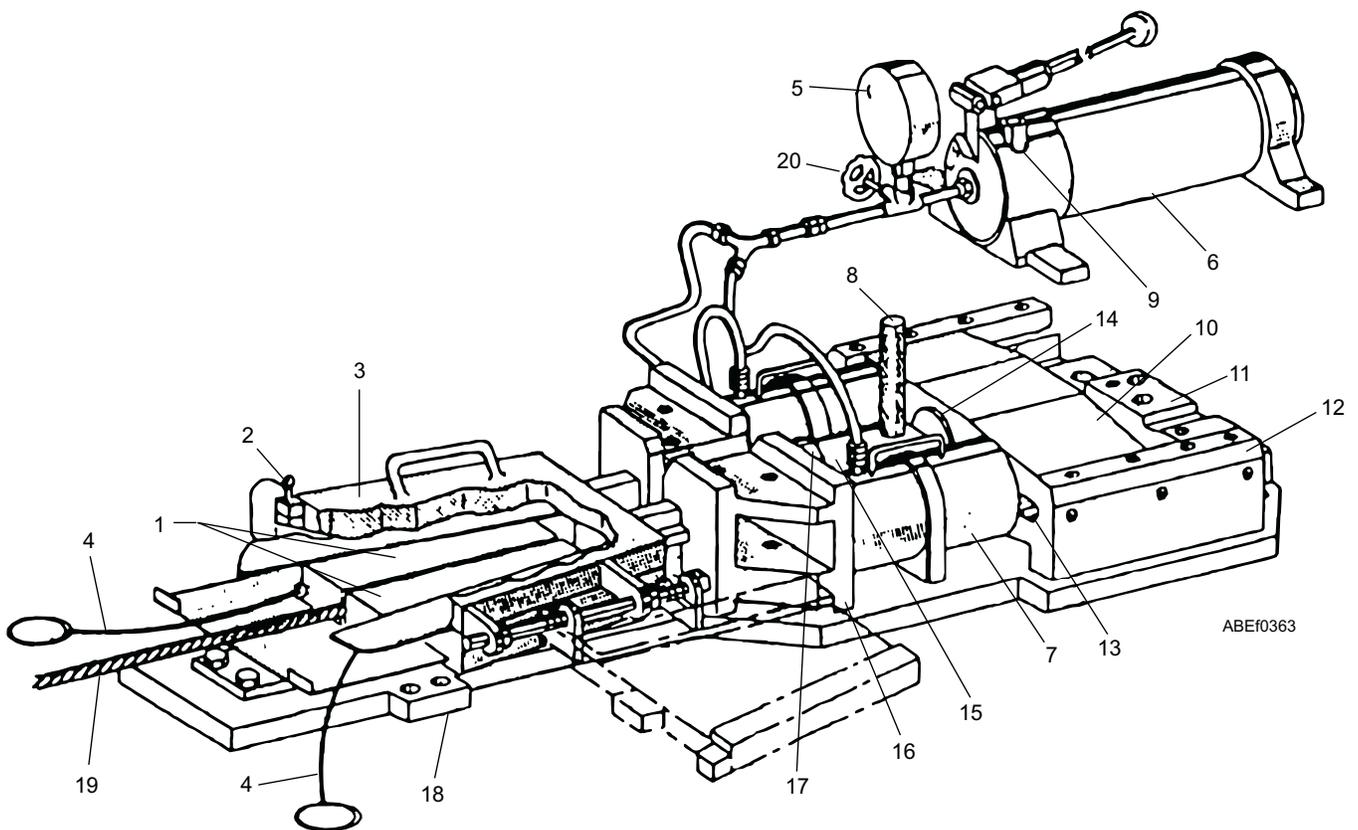
### Cable Terminal Proof-loading Machine

The cable terminal proof-loading machine is capable of providing a test load that substantially exceeds the test load required for testing the reliability of terminals used by ABEs. The test load is read on the tension gauge, which is calibrated in pounds, and is positioned in the line leading from the pump to the ram (see figs. 3-62 and 3-63).

The machine operating procedure is as follows (refer to fig. 3-63).

1. Thoroughly clean the portion of cable (19) that will be in contact with the wedge set (1) during the test. Do NOT use solvent for this cleaning operation.

2. Relieve all pressure in the hydraulic system by cracking open the external load-release valve (21) to slowly release the proof-load on the gauge. Slowly releasing the gauge load will prevent rapid snapback, with resultant possible breakage of the gauge pointer.
3. Manually move the crosshead away from rams and install the crosshead terminal.
4. Remove the safety lock pin and slide the lid toward the cylinders to open.
5. Install the wedge set, Lucker Manufacturing Company Part No. 3130-143 (for testing 1 7/16-inch-diameter purchase cable). Do not lubricate the cable gripping surface or the lid sliding surface.
6. Retract the wedges by pulling on the retracting cables. Lubricate the wedge sliding surfaces with PRELUB-6 before each test.



- |                        |                                 |
|------------------------|---------------------------------|
| 1. WEDGE SET           | 9. CONNECTING PIN               |
| 2. SAFETY LOCK PIN     | 10. CLEVIS SOCKET               |
| 3. GRIP ASSEMBLY LID   | 11. LOCK RING                   |
| 4. RETRACTING CABLES   | 12. CABLE TERMINAL              |
| 5. TENSION GAUGE       | 13. TENSION ROD                 |
| 6. HAND HYDRAULIC PUMP | 14. PURCHASE CABLE              |
| 7. HOSE ASSEMBLY       | 15. NEEDLE VALVE                |
| 8. RAM (CYLINDER)      | 16. EXTERNAL LOAD RELEASE VALVE |

Figure 3-63.—Wedge-type proof-loading machine (dual ram).

7. Screw the clevis socket on the cable terminal.
8. Place the cable between the wedges and connect the clevis socket to the crosshead terminal with the pin.
9. Manually move the crosshead into the rams, making certain that the adapter attached to each end of the ram engages its respective guide hole in the face of the crosshead.
10. Release the wedges, close the lid, and insert the safety lock pin.
11. Using chalk, masking tape, or some other means, mark the cable a measured distance from the wedge set. This procedure provides a means for checking cable slippage while the system is being pressurized.
12. Visually inspect the socket tester to make certain that all components are securely attached. Do not open the choker valve during operation of the hand pump, as this will result in excessive pressurization of the socket tester after the desired proof-load has been reached.
13. Open the choker valve (20) on the hand pump, and close the external load-release valve. Never apply proof-loading with the lid open, and keep hands clear of pin and crosshead area.
14. Using the hand pump, pressurize the system to increase the test load to 120,000 pounds. Hold the test pressure for 2 minutes.
15. As the pressure is gradually increased, observe the cable for evidence of slippage. If the cable begins to slip, proceed as follows:
  - a. Relieve the pressure as in step 2.
  - b. Remove the safety lock pin and open the lid. It may be necessary to first strike the lid with a soft mallet before it can be slid forward to open.
  - c. Retract the wedges.
  - d. Remove the cable and clean it thoroughly.
  - e. Clean and inspect the wedge gripping surfaces. Replace the wedges if necessary.
  - f. Lubricate the wedge sliding surfaces.
  - g. Repeat proof-loading procedures
  - h. Remove the cable from the socket tester and examine the poured terminal.

## REPLACING PACKINGS

The efficiency of any hydraulic equipment is directly dependent on the proper selection, preparation and installation of its packing. The replacement packing shall be only those that are called out in the assembly parts list. No substitutes or deviation in size or number shall be made. Prior to installation, the age of natural or synthetic rubber packing shall be checked to determine whether these parts are acceptable for use. A positive identification indicating the source, cure date, and expiration date shall be made. This information shall be available for all packing used.

The age control of all natural or synthetic packing shall be based upon the "cure date" stamped on the manufacturer's unit package, intermediate package, and shipping container. The cure date means the date of manufacture and is designated by the quarter of the year and year of manufacture. The cure date forms the basis for determining the age of the V-ring, O-ring packing, therefore, it becomes important that the cure date be noted on all packages. Packing manufactured during any given quarter will be considered one quarter old at the end of the succeeding quarter. For the purposes of explaining the coding used by manufacturers to designate the cure date, each year is divided into quarters as follows:

- First quarter: January, February, March
- Second quarter: April, May, June
- Third quarter: July, August, September
- Fourth quarter: October, November, December

The shelf-life control of all packing shall be governed by the "expiration date" stamped beside the manufacturer's cure date on each package. The expiration date is the date after which packing **CANNOT BE USED IN-SERVICE**. Synthetic and natural rubber packing and V-rings shall have a shelf-life limit of three years (12 quarters). Synthetic and natural rubber O-rings shall have a shelf-life limit of five years (20 quarters). Fluorocarbon O-rings, M83248/1-, have a shelf-life of twenty years (80 quarters). Thus, packing and V-rings shall be scrapped if not put into service within three years after the cure date, and O-rings shall be scrapped five years (twenty years for fluorocarbon O-rings) after the cure date. All packing shall be scrapped if not put into use before the time of the expiration date.

## Removing Old Packings

If practical, remove the shaft, ram, or other sealed members from the installation, since this permits inspection and correction of any defects in the shaft or packing assembly. Although it is preferable to remove the sealed member, limitations of time, design of the installation, or problems of reassembly often make the removal impractical. After the gland or flange is removed, the chief problem usually encountered is removing the female adapter. If this ring is provided with holes, insert a suitable hoop of bent and flattened wire, or a threaded rod if the holes are tapped, and pull the ring back along the shaft. The packing can be removed using a U-shaped pick made of copper or brass wire. The pick should be small enough to enter the stuffing box, and the ends should be bent and flattened. The pick should be inserted behind the ring, and the ring removed. It is usually not necessary to remove the male adapter. If the adapters are not provided with holes or if removal is difficult, they may be removed by alternate methods, such as inserting a wire or piece of flat stock behind the adapter and pulling it out (if sufficient space exists), or by bumping the shaft or stuffing box to dislodge the adapter. All traces of the packing must be removed and the stuffing box cleaned and inspected for scratches, burrs, or sharp edges. Rough spots or sharp edges must be honed down with a fine Carborundum stone. It is usually not necessary to replace the metal support rings or adapters when packings are replaced unless inspection shows failure, defects, or excessive wear.

## Installing New Packings

A V-ring packing housing generally consists of male adapters and female adapters. Either or both of the adapters may be designed as part of the gland or stuffing box. The adapters position and support the V-rings and form an efficient seal only when pressure spreads the lips of the rings firmly against the shaft, ram, or piston and against the walls of the stuffing box. To function properly, the female (open) side of the rings must face the pressure.

In double-acting installations, two opposing sets of packings are used with the open sides of each set facing away from each other. The female adapter must be inserted into the stuffing box first and seated properly. Each packing ring must then be inserted individually. Each ring must be seated carefully before the next ring is inserted. The rings must be seated with the aid of a flat tool or stick. To eliminate air trapped between the

rings as they are being inserted, collapse a short section of the ring by placing a thin rod of brass or other soft metal between the lips and the stuffing box wall. The male adapter, if used, must then be properly seated.

Extreme care must be exercised on installation to insure that the rings are not forced over sharp edges. A light coating of petrolatum conforming to the proper specification may be used if necessary, but excessive use must be avoided. Care is also taken that the rings or stuffing box wall is not damaged in any way.

## Gland Installation

Some of the packings of the engine may be spring-loaded. No gland adjustment is necessary on this type, since the springs normally allow sufficient float of the packing. If the gland is other than spring-tensioned, insert the gland and apply easy hand pressure until the gland touches the packing. Do not force it. If there is clearance between the flange of the gland and the body surface, withdraw the gland and insert one or more gaskets with a total thickness of from 1/64 to 3/64 inch greater than the distance between the gland flange and body surface. If there is metal-to-metal contact between gland flange and body upon application of hand pressure, the gland must be removed and the depth of the stuffing box must be measured. The length of the gland from the inner face of the flange to the surface that contacts the packing must be measured. This length must be subtracted from the depth of the stuffing box; if the difference exceeds 3/64 inch, a shim of the thickness of the excess must be removed or the gland flange must be machined to take up the excess. If the gland is the screw-in type, the procedure is the same except that the gland must be screwed in until contact with the packing is made and then backed off sufficiently to give a minimum of 1/64-inch and a maximum of 3/64-inch clearance between the gland and the packing. The amount of backup may be determined by counting the number of gland nut threads to the inch. For instance, if there are 10 threads to the inch, one revolution of the gland will give 1/10-inch clearance. If possible, the gland nuts should be lock-wired to prevent rotation.

## General Precautions Regarding V-Ring Packing

If leakage appears at the V-ring packing joint, check the gland flange for metal-to-metal contact with the body. Rework or replace parts as necessary, and if leakage continues, remove and examine the packing for damage or wear. A small leakage or "weeping"

generally appears when a V-ring packing has been replaced, but it usually ceases after operation. If leakage persists after operation, the packing may have unseated itself and the gland should be readjusted. If leakage persists after a reasonable adjustment, disassemble and check the stuffing box walls and the pistons for scoring, and check the packing for damage. Leaking packing must be replaced when adjustment does not stop the leakage. Excessive gland pressure must not be applied. V-ring packing under pressure from the gland not only functions improperly or wears out faster but also applies uncalculated forces on the ram, shaft, or piston, which may cause improper operation of the machinery. A clearance of 1/64 to 3/64 inch must be maintained to allow the packing freedom of movement. When there is clearance between the body and the gland flange, check the clearance at four points, 90° apart, to ensure that the packing or gland is not cocked before installing the gasket.

### REVIEW QUESTIONS

- Q13. What is the minimum allowable clearance between the crosshead and the crosshead stop?*
- Q14. What is the age of all packing based on?*
- Q15. What is the shelf life of V-ring packing?*
- Q16. When installing V-ring packing, what side faces the pressure?*

### SAFETY PRECAUTIONS

**LEARNING OBJECTIVES:** List the safety precautions associated with topside and deckedge areas. List the safety precautions associated with the arresting engine below decks. List the safety precautions associated with maintenance of aircraft recovery equipment.

Safety is not an accident. Safety is the result of trained personnel knowing their jobs and doing those jobs to the utmost of their ability. Attention to every detail, concern over every function, and awareness of malfunction will nullify the possibility of accident from improper operational procedures. Mechanical failure cannot be completely neutralized, but trained personnel can make such a failure a rarity.

Recovering aircraft involves various inherent dangers, due to the complex coordination of personnel and machinery. Personnel engaged in the operation of the arresting gear equipment must be thoroughly

trained and indoctrinated in the operations. Disregard for the fundamentals of caution and safety creates hazards far in excess of the previously mentioned inherent danger factors.

All operating personnel must understand the importance of accurate commands, attention to commands, and proper care of communications systems. The system may be phones, synchro signals, or lights, and must be operational at the time of use. Accuracy in making proper settings of gears, indicator systems, tension, and pressure tests must be emphatically impressed on all personnel.

The following general safety observations are arranged according to location, and copies should be supplied to all applicable stations.

### TOPSIDE AND DECKEDGE AREAS

During arrestment, all topside and deckedge personnel should be aware of all movement on and about the deck, with strict attention paid to the landing aircraft. Deckedge control operators should duck below deck level during pendant arrestment in the event of pendant breakage or failure that would cause cable whip or the aircraft to go over the deck edge.

#### Hook Runners

Hook runners should approach aircraft from the front and side. This will place them away from danger of jet blast or broken cable backlash.

#### Overcrowding

Catwalk personnel should be held to a minimum so they can exit quickly should they be placed in jeopardy.

#### Barricade Readiness

Rapid fuel consumption by jet aircraft requires highly trained, responsible crews for rigging the barricades. Regular drills in rigging should be held to reduce rigging time to a minimum.

#### Walkback

Air in the main engine cylinder or the CRO valve does not seat properly are the major causes of walkback. This is an extremely dangerous occurrence, as the pilots have no control over the aircraft in addition to being unable to see where they are going, thus the aircraft may go overboard, endanger deckedge

personnel, or cause injury to personnel on deck not paying attention to what is happening around them.

### **Pendant Retraction**

The retracting cycle of the deck pendant is normally executed at full speed. The operator, prior to pulling the retracting lever, must ascertain that no personnel or equipment are in a position to be struck during retraction. If for any reason a sudden interruption of the retracting cycle occurs, the same precaution must be taken prior to the resumption of the retraction cycle.

### **Wire Supports**

Broken or deformed wire supports should be replaced as soon as practical.

### **Stanchions**

Personnel should stay clear of areas where stanchions are being raised or lowered, and particularly when barricades are being raised or lowered. When stanchion repair is to be effected, the stanchions safety brace must be installed.

### **Terminals, Fittings, and Cables**

Frequent inspection of all cables, terminals, and fittings should be maintained. Any indication (no matter how slight) of failure should be corrected immediately. Particular attention should be given to terminals jamming sheaves. Any condition where this is evident is extremely critical. The unit involved should not be operated until correction of the condition is made.

### **Sheaves and Winches**

Generally all sheaves should be free running, have no indication of turning of the lips, or indication of jamming by terminals. No slippage of the sheave on races should be evident, and any fault of this nature should be corrected. Winches should be checked for running and positioning. Both sheaves and winches should be kept clean of debris or foreign matter, and be regularly lubricated.

## **BELOW DECKS—THE ARRESTING ENGINE**

The greatest safety factor in the operation of the arresting engine is constant attention to inspection, maintenance, and overhaul. Preventive maintenance is

particularly necessary. Daily inspection, inspection after each arrestment, and depending on the unit involved, inspection and maintenance at regular intervals nullify many of the conditions that might arise to endanger operating and flight personnel. Always keep hands and body clear when engine is operating or in a condition to become operable.

### **Weight Selector Settings**

The safe arrestment of incoming aircraft can be directly attributed to proper setting of the aircraft weight selector. Aircraft weight selector settings should always be made according to current aircraft recovery bulletins. Maximum efficiency is obtained from the arresting engine through proper weight settings. There is one distinct error in arrestment that can be directly attributed to improper weight settings or error in the gross weight estimate. This error results in TWO-BLOCKING the engine.

TWO-BLOCKING is a condition in which the weight selector is set too light for the incoming aircraft. This condition causes the ram to ride forward into the cylinder until the crosshead bangs into the mouth of the cylinder. A wooden block assembly, called a ram block, is positioned at the crosshead end of the ram to act as a shock absorber by preventing metal-to-metal contact between the crosshead and the mouth of the cylinder.

BOUNCEBACK is the movement of an arrested aircraft backward and is caused by the stretch inherent in the purchase cables. Bounceback is desirable because the hook is disengaged, allowing rapid deck clearance for future landings. Pilots are instructed to allow for bounceback before braking.

### **Control Valve Failure**

Prime failure, with resultant disastrous consequences, could be failure of the drive system that would result in improper opening or closing of the CRO valve. Cam alignment is equally important, as improper alignment would result in fluid flow through the CRO valve at a ratio different from that indicated on the aircraft weight selector indicator. Thus, while the operator would have an indication of a proper setting, actual flow control would be different.

### **Drive System Hazards**

Much of the cable system is contained behind U-channels to protect personnel during operation. This cable, with connections, is subject to wear and fatigue

and should be checked against failure. Failure of the drive system could cause serious injury to operating and aircraft personnel.

### **Excessive Pressures**

The accumulator is built to take a 400-psi initial charge and such additional pressure as is developed during arrestment. This capacity provides for an overloading factor. However, it is most important that the accumulator blow-down valve on the charging panel be kept open. Should leakage occur from high-pressure piping as the result of inadequate valving, this, with the additional compression loading during arrestment, could cause an extremely dangerous accumulator pressure. One operating indication of excessive accumulator pressure is retraction that exceeds normal speed. Initial accumulator pressure must be held at 400 psi. A safety diaphragm is installed on the air side of the accumulator to eliminate the possibility of an accumulator explosion.

### **Fluid Level Indicator Safety**

When the engine is in BATTERY position, the fluid level indicator must read BATTERY. Should any other reading be indicated, the engine must not be operated until a battery indication is effected.

### **Malfunctions and Safety**

Personnel must always be certain that their method of operation is not responsible for a malfunction. Possible malfunctions, causes, effects, and remedial action are listed in *Operational and Organizational/Intermediate Maintenance Manual with Illustrated Parts Breakdown, for all Shipboard Aircraft Recovery Equipment, NAVAIR 51-5BBA-2.1 and 2.2.*

## **SAFETY IN MAINTENANCE**

Any engine not operable or shutdown because of malfunctions, breakdown, needed adjustment, or repair should have the deck pendant removed and all operating pressures relieved. Leaks indicate poor fittings or bad packing and result in pressure losses and probable malfunction. Every leak must be immediately investigated to determine the cause and the corrective action to be taken. Cleanliness concerning debris, waste wiping materials, and tools must be very strictly adhered to, particularly where involvement with operable parts may occur. A jammed up engine as a

result of carelessness with work materials could result in injury and/or loss of life. Lubrication tables for all equipment must be strictly adhered to. Venting the various lines to remove entrapped air, foam, or waste fluids is a preoperational and operational requirement. Safe operations depend upon strict adherence to these and all other pertinent safety instructions.

### **Molten Metal and Heating Methods**

A detailed description of heating and using molten metal for pouring sockets is contained earlier in this chapter. Particular attention should be given to the warning notes and instructions regarding personnel safety. All personnel involved in terminal pouring operations or in any operations where molten metals are involved should wear goggles, gloves, aprons, and such other protective clothing as is necessary. Ample ventilation must be provided against fumes given off by molten metals.

### **Cables, Pendants, and Taut Lines**

In running pendants, cables, or taut lines, personnel should be familiar with procedures so that equipment is placed without kinking, twisting, or unnatural positioning. Improper handling of cables will cause strand breakage and subsequent weakening and failure. Whenever deck tractors are used for pulling out pendants, all personnel must be on guard for cable lash.

### **Improper Landings**

Personnel at deckedge stations or on deck duty must be alert during landing operations to stay clear of any aircraft and particularly those making offcenter or excessive-speed landings. Either type can lead to pendant failures, unequal stanchion loading in the event of barricade landings, and the possibility that such aircraft will go over the deck edge.

### **Safety Checklist**

The following safety checklist should be posted at applicable locations:

- Replace broken, worn, or kinked deck pendants and barricade deck cables as soon as operations permit.
- Inspect deck pendants after each group of landings and after each excessive-load landing, such as extreme offcenter landings or extreme runoff to two-blocking.

- Lubricate deck pendants and barricade cables properly and frequently.
- Replace broken wire supports.
- Raise the barricade webbing to the proper height.
- Replace loose or damaged cable fittings and couplings.
- Do not allow terminal jamming of deck sheave housing.
- Remove debris and dirt from all areas.
- Remove the deck pendants from engines that are inactive.
- Keep stanchion area clear of personnel when raising and lowering cables and webbing assemblies.
- Do not reuse the barricade webbing system after an arrestment.
- Hookrunners should approach all arrested aircraft from the front to avoid jet blast and possible broken cable backlash.
- Keep flight deck clear of personnel until aircraft has come to a stop.
- Install barricade stanchion safety brace before making repairs.

### REVIEW QUESTIONS

*Q17. How should hook runners approach an aircraft?*

*Q18. What can cause walkback?*

*Q19. Before making repairs to the barricade stanchions, what must be installed?*

*Q20. What is the condition that can cause two-blocking?*

*Q21. What is an indication of excessive arresting engine accumulator pressure?*

### SUMMARY

You should now be able to describe the operation and function of the arresting gear engine systems; various operational and maintenance procedures; procedures to remove and replace crossdeck pendants; the barricade webbing to the stanchions; procedures used to dereeve and reeve arresting gear engine purchase cables and the procedures used to prepare, pour, and conduct proof-load tests on the wire rope terminals.

As important as the procedures are, you should now know to keep safety uppermost in mind. The safety precautions in force today have been bought many times over through reduction in damaged equipment, personnel injuries, and fatalities.

For complete recovery equipment operation, maintenance, overhaul, and safety instructions refer to *Operational and Organizational/Intermediate Maintenance Manual with Illustrated Parts Breakdown, for all Shipboard Aircraft Recovery Equipment, NAVAIR 51-5BBA-2.1 and 2.2.*

